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ABSTRACT

This curriculum guide is designed for use with the Charles E. Merrill textbook "Focus on Earth Science" and with the laboratory manual, teaching guide, and student review and reinforcement guide which accompany the textbook. Suggested time allotment, major concepts, instructional objectives, assessment items, available materials (such as films, charts, models, and transparencies), and suggested activities are provided for chapters 12 to 25. These chapters focus on: erosion, mass movement, and wind; water systems; glaciers; earthquakes; plate tectonics; landforms; geological dating; geologic time; renewable and nonrenewable resources; energy resources; universe, galaxies, and stars; solar system; and space voyage and exploration. Enabling objectives for essential learner outcomes, basic objectives which each teacher must teach but not requiring 100 percent student mastery, assessments and activities requiring minimal reading skills, and assessments and activities for accelerated students are noted when applicable. Supporting materials provided in an appendix include activities on rockets, measurements, and tides; tips for maintaining saltwater aquariums; and a list of animals found in bottom communities of the upper Texas coast. (JN)

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EARTH SCIENCE

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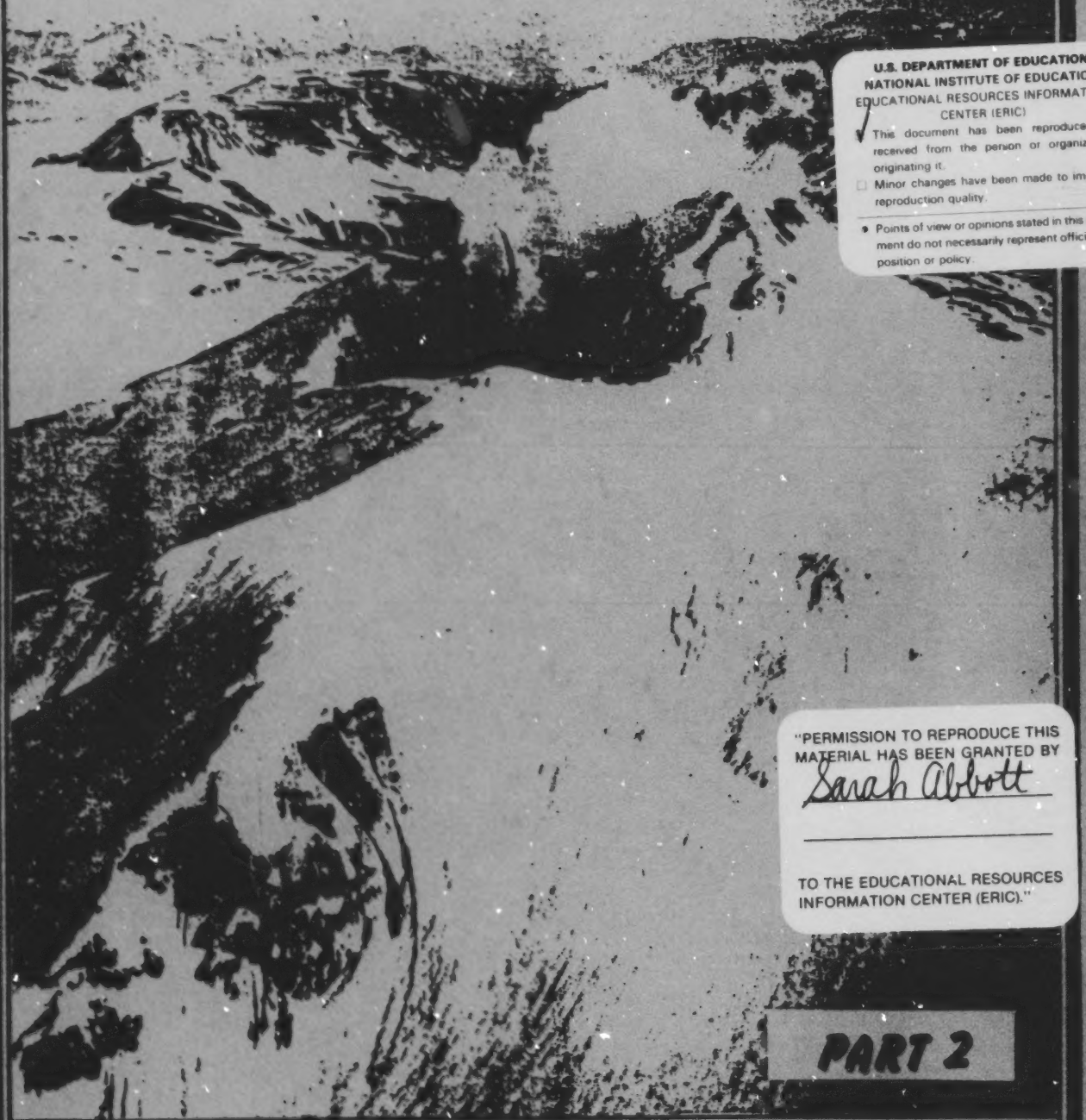

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PART 2

Houston Independent School District
Houston, Texas

Curriculum Bulletin 81CBM63

Item Number 33.2471

EARTH SCIENCE

GRADE 8

PART II

Curriculum Bulletin Number 81CBM63

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UNIT IV

EARTH SURFACE PROCESSES

Chapter 12: Erosion, Mass Movements and Wind

(Time Allotment - 4 days - One Semester)
8 days - Two Semesters)

Major Concepts to be Taught

Erosion and the factors influencing erosion
Mass Movement
Winds as an erosional agent
The types of deposits caused by winds

Essential Learner Outcome

The student will -

Describe one way each that wind, moving water, and freezing water can change the surface of the earth.

Instructional Objective

The student should be able to:

e . define erosion and list the agents of erosion
. define the types of mass movement
e . describe how wind erodes the earth's surface
. discuss the unique characteristics of loess and name its source
. determine which factors affect the kinds of sand dunes created by wind.

Assessment Guidelines

The student will:

. Define loess.
. List sources of loess.
. List factors which determine the distance and height to which material is carried by the wind.
. Conduct an experiment to demonstrate the results of wind on different surface materials.
. Define deflation and abrasion.
. Describe the causes of the "dust bowl" of the 1930's.
. Use a map to locate the "dust bowl."
. Compare and contrast sand particles carried by wind and those carried by water.
. Define oasis and describe its formation.
. Describe the structure of wind-eroded rock.
. List three kinds of rock material deposited by wind.
. Differentiate the formation of transverse, barchan and parabolic sand dunes.
. Name some land forms that result from wind erosion and deposition.

Materials

Textbook: Focus on Earth Science, pages 220-241

Lab Manual: "Earth Science - A Learning Strategy for the Laboratory
No. 36 - Mass Movement

Earth Science Activity-Centered Program, Teacher's Guide
Page 93, Additional Activity
Page 96, Extensions to Activity 12-1
Page 97, Extensions to Activity 12-2
Page 97, Additional Activity

Focus on Earth Science Review and Reinforcement
12:1 - Erosion by Mass Movements and Wind, page 59
12:2 - Erosion Puzzles, pages 59-60
12:3 - Dune Shapes, pages 60-61
12:4 - Sand Dunes

Additional Suggestions

Study questions - A, B, C, pages 239-241
Points to Remember, page 239
Words to Use, page 239
How and Why, page 241
More Ideas to Explore, page 241

Films:
4333 - Erosion (1968) 11 min.

PERFORMANCE OBJECTIVES	SUGGESTED ACTIVITIES
The student will -- e Define erosion and list the agents of erosion.	As a group, define the word erosion and list the agents of erosion. Skillcard No. 23 - Observable Changes. This is a long range activity involving the observation of natural erosion in the community. The class could make a bulletin board on the agents of erosion by finding pictures of rivers, wind, underground water, ocean waves, currents, and glaciers.
Define and identify types of mass movement.	Have students do Lab No. 36 - Mass Movements, page 81 of Lab Manual. In this experiment, students will cause mass movements and classify them. Students could do Exercise 12:1 - Erosion by Mass Movements and by Wind, page 59 of the Review Guide. Read about recent disasters caused by mud or landslides. Have students report on the types of mass movement in the Houston area. These movements may include slump, in which a mass slides down a slope but retains its unity, creep, in which vegetaion holds the surface soil together as it gradually slides downward.
e Describe how wind erodes the earth's surface.	Define oasis. Have students do the experiment on page 229. In this activity, the student will examine the effects of wind on different types of material under different conditions. @ Students could report on wind blown volcanic ash from the volcano Mt. St. Helens (1980-81) or Irazu in Costa Rica (1963-64). Students could prove that air has resistance. Have them do the Activity on page 93 of the Activity Book. Research the "dust bowl" of the 1930's.

PERFORMANCE OBJECTIVES	SUGGESTED ACTIVITIES
The student will -- Discuss unique characteristics of loess and name its source.	Have students do More Ideas to Explore, No. 1 on page 241. Have students go to the library and research the formation and deposits of loess around the world. In a written report, have them indicate where large loess deposits can be found.
Determine which factors affect the kinds of sand dunes created by winds.	Have students do More Ideas to Explore on page 241. Have students do the activity "Kinds of Sand Dunes." Make copies for your students. Have students do activity "Winds and Deserts." Make copies for your students. Have students do the Extension to Activity 12-2, on page 96 of the Activity Guide. Have students do the Additional Activity on page 97 of the Activity Book. In this activity, students will demonstrate the wind shadow zone. Students could plot the distance and depth of sand on a graph. See page 60 of the Review guide for more details. Use information found in Table 12-1 page 236 of the textbook to answer questions about wind blown sand deposits. See page 62 of the Review guide for more information. Have students do Focus on Skills, page 238 of the textbook.

WIND AND DESERTS

Problem: How can you show the effects of wind on sandy deserts?

Materials:
- Cardboard box
- whisk broom
- knife
- sand
- pencil
- safety glasses
- metric ruler
- atomizer or spray bottle
- water
- small rocks
- multispeed fan or hairblower

Procedure:

1. Carefully cut the top and one end out of the cardboard box.

2. Draw a line across the bottom of the box halfway between the open end and the closed end. Draw parallel lines across the bottom of the box every centimeter from the center line to the closed end of the box.

3. Place a layer of dry sand about two centimeters deep from the open end of the box to the center line.

4. Turn the fan or hair blower on low and direct the flow of air onto the sand for about 30 seconds. How many of the parallel lines are partially covered by the sand? Which lines have the most sand between them?

5. Sweep the sand back in front of the center line. Turn the fan or blower on high and direct the flow of air onto the sand for 30 seconds. How did increasing the speed of the air flow affect the movement of the sand?

6. Sweep the sand back in front of the center line. Turn the fan or blower high and direct the air flow onto the sand for one minute. How did increasing the amount of time that the fan or hair blower blew on the sand affect the movement of the sand?

7. Sweep the sand back in front of the center line. Place some rocks on the sand. Turn the fan or hair blower on low and direct the air flow onto the sand for 30 seconds. How is the movement of sand affected by the rocks?

8. Remove the rocks and sweep sand back in front of the center line. Use the atomizer or spray bottle full of water to moisten the sand. Turn the fan or hair blower on low and direct the air flow onto the sand for 30 seconds. How does moisture affect the movement of the sand?

KINDS OF SAND DUNES

Problem: What factors affect the kinds of sand dunes the wind creates?

Materials:
- Safety glasses
- 2 flat pans
- 2 liters clean sand
- twigs
- small grass clump
- angular stones
- 2 speed hair dryer

Procedure:

1. Label the pans A and B. Put clean dry sand into each pan.
2. In pan B, arrange stones at one end and place twigs and grass in different areas throughout the sand.
3. Turn the blower on low speed. Hold it at a 45° angle, 10cm from pan A for one minute. Record all observations in your table. Repeat with pan B.
4. Change to the blower's high speed. Hold it at an angle of 45°, 10cm from pan A for one minute. Record the wind's effect in the table. Repeat with pan B.
5. Sketch diagrams of the dune(s) which appear in each pan.
6. Level the sand in pans A and B. Repeat Steps 3 through 5 for each pan blowing the air for 3 minutes each time.

Blower speed	Pan A		Pan B	
	1 Min	3 Min	1 Min	3 Min
Low				
High				

Results and Conclusions:

1. Describe any dunes that appear in Pan A at the end of one minute using low speed on the blower and using high speed.
2. Describe any dunes that appear in Pan B at the end of one minute using the low speed on the blower and using high speed.
3. Describe the effect of different wind force on dune formation.
4. Describe the effect of different time lengths on dune formation.
5. Using pages 311 and 312 in your textbook try to identify the type(s) of dunes formed in this activity.
6. Why is it advisable to plant vegetation in sandy areas?

CHAPTER 13: WATER SYSTEMS

(Time Allotment: 4 days - One Semester)
8 days - Two Semesters)

Major Concepts to be Taught

Development of the river systems
River deposits
Erosion by rivers
Zones of movement of ground water
Erosion by ground water
Ground water deposits

Essential Learner Outcomes

The student will -

Describe one way each that wind, moving water, and freezing water can change the surface of the earth.

List at least two conditions that exist on planet earth that enables life as we know it to exist.

Instructional Objectives

The student should be able to:

B . define runoff and identify the factors that affect runoff
. describe the type of erosional processes in arid and humid climates and the topography that is produced by this erosion
B . define, identify, and describe the characteristics of the three stages of a river
e . describe the formation of a river system and how it changes the earth's surface
B . identify the terminology and zones associated with underground water and explain how water moves through crustal material
. associate the difference between "hard" and "soft" water and realize that water does contain minerals
. explain what geysers are and what causes them
B . realize that underground water is responsible for the formation of various types of mineral deposits and unusual features in limestone regions
e . recognize the vital importance of ground water to life on earth

- Define erosion and name three agents of erosion.
- Define runoff and name four factors affecting runoff.
- Name the three stages of river development.
- Identify from profile drawings of river channels the three stages of a river.
- Define five of these terms:

gradient	steam load	oxbow lakes
volume	meanders	river valley
velocity	tributaries	drainage basin

- Make a sediment jar with sand, clay, and gravel and explain the order in which they settle and why.
- Explain where and how a river delta forms.
- Explain capillary attraction.
- Give reasons why the depth of the water table is not constant.
- Define four of these terms: permeable, porous, impermeable, aquifer, artesian water, springs, seeps.
- Define water table.
- Describe the features formed by the action of rainwater in dissolving limestone.
- *Describe the action of a geyser.
- Describe how caves are formed.
- Name the cave structures that are formed by the dripping of water containing calcite.
- List ways that groundwater is used.
- Name some dangers to our groundwater supply and give several solutions to controlling our water problem.
- Suggest possible ways of conserving ground water.

Materials

Textbook: Focus on Earth Science, pages 242-261

Earth Science Skillcards:
- No. 23 - Earth's Crust - Observable Changes
- No. 51 - Running Water - Volume and Velocity
- No. 52 - Running Water - Slope and Velocity
- No. 53 - Running Water - Deposits, Part I,
- No. 54 - Running Water - Deposits, Part II,
- No. 55 - Running Water - Ground Cover, Part I
- No. 56 - Running Water - Ground Cover, Part II
- No. 57 - Running Water - Contour Plowing
- No. 58 - Groundwater - Soil Moisture for Introduction
- No. 59 - Groundwater - Capillary Attraction
- No. 61 - Groundwater - Water Table
- No. 62 - Groundwater - Underground Deposits
- No. 68 - Hydrologic Cycle

Lab Manual: Earth Science - A Learning Strategy for the Laboratory
- No. 37 - Runoff
- No. 38 - Transporting Soil Materials by Runoff
- No. 39 - Capillary Action
- No. 40 - Rivers
- No. 41 - Permeability
- No. 42 - Carbon Dioxide and Limestone

Earth Science Activity-Centered Program, Teacher's Guide
- Page 102, Extensions to Activity 13-1
- Page 103, Additional Activity
- Page 105, Additional Activity
- Page 107, Extensions to Activity 13-2

Focus on Earth Science Review and Reinforcement Guide
- 13:1 - River Erosion, page 63
- 13:2 - River Channel Changes, pages 64-65
- 13:3 - Groundwater Pollution, pages 66-67
- 13:4 - Earth Features Formed by Water, page 68

Additional Suggestions:
- A,B,C, pages 259-261
- Points to Remember, page 359
- Words to Use, page 259
- How and Why, page 261
- More Ideas to Explore, page 261
- Collect pictures of all types of rivers
- Trace on a map the river system of Texas

Films:
- 4333 - Erosion (1968) 11 min.
- M4329 - Caverns and Geysers
- 4702 - Winter Geyser
- The Bahamas, Where Limestones Grow Today, 40 min. (Available on loan from the Humble Oil and Refining Company)

PERFORMANCE OBJECTIVES	SUGGESTED ACTIVITIES
The student will -- Define runoff and identify the factors that affect runoff.	As a group, define the term runoff and identify the factors that affect runoff. Stress that runoff depends on many different factors. Students can construct models showing runoff. Students could do library investigation on floods and problems caused by flooding. Students should include in their report where the three major floods in the United Statres occurred in the 1900's. What methods are now being used to control floods. Have students observe runoff in their communities after a rain. Lab 37, page 83, of the lab manual is an investigation into the effect of ground cover on the amount of runoff. Skillcard No. 51 - Volume and Velocity and Skillcard No. 52 - Slope and Velocity seem to be excellent activities on factors that affect runoff. The visual effect for these activities should be very good, but problems may occur in the actual setting up of the materials. The reward may be worth the effort. *Skillcards No. 55 - Ground Cover, Part I, No. 56 - Ground Cover, Part II, No. 57 - Contour Plowing are very simple activities on what affects runoff. The materials and procedures involved require little work, but there is a time factor on Skillcard No. 56. (Allow 3 WEEKS to grow rye grass in a pan.) Lab No. 38 - Transporting Soil Material by Runoff, page 85 of Lab Manual.
Describe the type of erosional processes in arid and humid climates and the topography that is produced by this erosion.	Students could report on the badlands. Students could construct models showing the similarities of water deposits in river regions and arid regions. Compare and contrast a delta, an alluvial fan, and mesas. Have students do a library investigation on Death Valley, California.

PERFORMANCE OBJECTIVES	SUGGESTED ACTIVITIES
The student will -- Describe the formation of a river system, and how it changes the earth's surface.	Make a map of your school grounds. After a heavy rain, have students to explore the school grounds. Students should sketch in the patterns of riils. Also, have them observe the effects of the rain. Have students determine where the water joins to form a creek or stream. Have students define profile of equilibrium and conduct a class discussion on how drainage systems may change and how the river adjusts its profile to these changes. Have students do Making Sure No. 1, page 246 of the textbook. Students should determine how the slope of a stream affects its velocity and load by doing the Activity on page 247 of the textbook. Students could do River Erosion, page 63 of the Review Guide. Sketch a meander and show where erosion and deposition occur. Have students do the activity on page 103 of the Activity Book. In this activity, students will determine what causes a stream to meander. Have students do exercise 13:2 River Channel Changes. In this exercise students will plot depth measurements of a river at three different locations. Skillcard No. 53 - Deposits, Part I, has the students make a sediment jar and observe the rate and order of settling. *Skillcard No. 54 - Deposits, Part II, may best be worked as a demonstration involving the help of a few students. This activity shows how the transporting rsate of a river is dependent on the velocity of the water.

PERFORMANCE OBJECTIVES	SUGGESTED ACTIVITIES
The student will --	Find a detailed map of the river systems in the Texas Gulf Coast region and let the students outline the river patterns and identify the rivers. Obtain a detailed map of Harris County streams, bayous, and rivers. Students should notice the meandering of these water systems. Have students do Lab No. 40 - Rivers. Students will investigate the information of deltas. Students could determine how damming affects stream velocity. Have them do the activity on page 105 in the Activity Book. @ Read about famous rivers of the world, such as the Nile, Amazon, Rhine, Volga, and Ganges. Students could do a library investigation comparing lakes and rivers of different continents. Find out which continent has the most lakes, which has the fewest; which has the most rivers, which has the fewest; which continent has the longest river, and which river carries the most water. @ Have students look up geologic and topographical information about waterfalls. Interested students could prepare a report on the attempt by the American and Canadian governments to halt the erosion of Niagara Falls. Have students do a library investigation about how the Grand Canyon was formed. Have them to present an oral report to the class.
Identify the terminology and zones associated with underground water and explain how water moves through crustal material.	*Skillcard No. 58 - Soil Moisture. A very simple activity to detect moisture in the soil. *Skillcard No. 59 - Capillary Attraction and Activity No. 1 on page 271 are very similar and should be helpful in explaining capillary attraction. Have students do Lab No. 39 - Capillary Action on page 87 of the Lab Manual. Skillcard No. 61 - Watertable. This activity involves digging until the water table is reached. A suggested site is near a river, lake, or ocean and those students who go on weekend family outings may find such a digging site. An alternate suggestion is offered for the classroom.

PERFORMANCE OBJECTIVES	SUGGESTED ACTIVITIES
The student will --	*Copy a drawing of Figure 13-2 on page 255 for student's notebook. The experiment on page 91 of the Lab Manual will help the students compare the permeability factor of different sediments. Have students do More Ideas to Explore, No. 1, on page 261 of the textbook.
Describe how underground water forms various types of mineral deposits and unusual features in limestone regions.	Students could do the activity "Chemical Water Softeners." Have students demonstrate how the water table changes. See page 107 of the Activity Book for details. Differentiate between stalactite and stalagmite. Students could report two of the well-known limestone caverns: Carlsbad Caverns, New Mexico, and Mammoth Cave, Kentucky. *Skillcard No. 62 - Underground Deposits. From this activity the students can see how the tightly packed layers of sediments can hold water and even gas or oil. Activity on page 278 demonstrates how underground water transports materials. Lab No. 42 - Carbon Dioxide and Limestone. Students will see how carbon dioxide forms a weak acid. Have a "show and tell" on caves that the students have visited.
Recognize the vital importance of ground water to life on earth.	List the ways groundwater is beneficial to man. @ Determine where the city of Houston gets its water supply. This topic could be discussed in great detail/researched/debated. Students could read about the problem of subsidence in the bay area. Since subsidence can be caused by drilling for oil and gas, this subject could be discussed with Section 22:7 and 22:8. Have students read Focus on People, page 258 of the textbook.

NAME _____ Period _____ Date _____

CHEMICAL WATER SOFTENERS

Problem: How does a chemical water softener affect water's ability to form suds?

Materials:
- different samples of water (6)
- borax or washing soda
- watch (with second hand)
- small (10cm or 4 in.) bottles with corks or caps (14)
- glass-marking pencil
- distilled water
- soap
- medicine dropper

Procedure:

1. Make a soap solution by dissolving a piece of soap about the size of a walnut in 1/2 liter (about 1 pint) of water.

2. Collect samples of water from different places in your community, such as from a spring, a stream, a lake, a bayou, a well and a faucet. Place distilled water in one pair of bottles. Label each sample of water.

3. Use a medicine dropper to place ten drops of the soap solution in one of the samples of distilled water. Close the bottle and shake it for ten seconds. Then lay the bottle on its side. Observe the soapsuds inside the bottle. If no soapsuds remain at the end of a minute, continue to add the soap solution one drop at a time until some soapsuds remain at the end of a minute. In the following table, record the total number of drops of soap solution needed for the distilled water sample.

4. Repeat step 3 described above with the different samples of water you collected. Record your data in the table.

5. Repeat steps 3 and 4 with the other set of samples, but this time treat each water sample by dissolving a few crystals of either borax or washing soda in each sample before adding the soap solution. Again record the total number of drops of soap solution needed for each sample.

Sample of Water	Source of Water	Number of Drops of Soap Solution	
		No Water Softener	Treated With Water Softener
1	Distilled		
2			
3			
4			
5			
6			
7			

Results and Conclusion:

1. Using the date you recorded in the table under No Water Softener, which sample of water was the softest? That is, which required the fewest number of drops of soap solution before soapsuds remained at the end of a minute? Which sample of water was the hardest?

2. List all seven samples in order of hardness, beginning with the softest.

3. Why is the method you used in this activity a way of determining the relative hardness of water, rather than the actual hardness of water?

4. How were the results of the activity different when the samples were treated with a water softener?

5. What conclusion can you draw from your results when the chemical water softener was added to the water samples?

CHAPTER 14: GLACIERS, THE WORK OF ICE

(Time Allotment: 2 days - One Semester)
5 days - Two Semesters)

Major Concepts to be Taught

Formation of glaciers
Glacial erosion and deposits
Evidence of glaciation
Theories of glacial origin

Essential Learner Outcome:

The student will -

Describe one way each that wind, moving water, and freezing water can change the surface of the earth.

Instructional Objectives

The student should be able to:

B . list the factors necessary for glacial formation and recognize the different types of glaciers according to their location.
e . identify the features of glacial erosion and describe the magnitude of this form of erosion.
. identify types of glacial deposits and explain how they were formed.
. describe the relationship between sea level and glaciation.
. discover that glaciers leave behind very good clues and that from these clues the Ice Age has been studied in great detail and theories of its origin have been developed.

Assessment Guidelines

The student will:

. Define or describe a glacier.
. *List conditions necessary for glaciers to form.
. List the three types of glaciers.
. Define abrading and plucking as they relate to glacial erosion.
. *Name the type of glacier that covers Antarctica.
. *Describe the physical differences between the Arctic region and the Antarctic region.
. *On a drawing of glacial erosion, identify these features:

cirque	esker	moraine
horn	hanging valley	

- Describe the appearance of three terms related to glacial erosion:
  cirque esker moraine
  horn hanging valley
- Underline these statements which correctly describe a glacier:
  a. Glaciers occur in low altitudes and arid regions.
  b. Glaciers occur in regions of perpetual or permanent snow.
  c. Glaciers may form if new snowfall counterbalances melting.
  d. Glaciers form in mountains if snow reaches a depth of several hundred feet and stays in place for many seasons.
  e. Temperature and precipitation determine the formation of a glacier.
  f. Glaciers are the most powerful force of erosion.
  g. Bottom ice of a glacier becomes plastic under pressure.
  h. A glacier moves forward because it is melting.
  i. A glacier moves forward because of the pull of gravity.
  j. Depositional features of a glacier includes moraine, eskers, levees, deltas, kames.
  (CORRECT ANSWERS ARE: b, c, d, e, g, i)
- *List some of the landmarks of the United States that were formed by the Ice Age.

Materials

Textbook: Focus on Earth Science, pages 262-279

Earth Science Skillcards:
- No. 28 - Earth's Crust - Glacier for Section 15:3, page 291
- No. 29 - Earth's Crust - Icebergs for Sections 15:4, page 294

Lab Manual: "Life Science - A Learning Strategy for the Laboratory"
- No. 43 - Model Glaciers
- No. 44 - Glaciation and Sea Level

Earth Science Activity-Centered Program, Teacher's Guide
- Page 111 - Extensions to Activity 14-1
- Page 113 - Extensions to Activity 14-2

Additional suggestions:
- A, B, C, pages 277-279
- Points to Remember, page 277
- Words to Use, page 277
- How and Why, page 279
- More Ideas to Explore, page 279
- Pictures of glaciers and glacial erosion

Films:
- 5922 - Legacies of the Ice Age (glaciers) 1971 - 12 min.
- L4488 - White Wilderness - Part I and Part II
- M4630 - Antartics - Coldest Continent
- L2699 - Secrets of the Ice

PERFORMANCE OBJECTIVES	SUGGESTED ACTIVITIES
The student will -- List the factors necessary for glacial formation and recognize the different types of glaciers according to their locations.	Students could list all of the factors necessary for glacial formation. This could be followed up by having them indicate the present position of ice caps and glaciers. *Experiment on page 266 involves the factors that influence the melting of ice. Have students do a library investigation to find out about the Ice Age. In the report students should include a map showing the major glaciers found in North America today. Also show the area of North America that was covered by continental glaciers in the past. Students should answer the following questions: (1) When do scientists believe the Ice Age occurred? (2) What do scientists think causes Ice Ages? (3) How far south did the ice sheets extend into North America? What evidence exits to support this finding? Ask students to compare and contrast valley, piedmont, and continental glaciers. Students should do Lab 43 - Model Glacier on page 43 of the Lab Manual. In this activity students will construct a model of a valley glacier.
Identify the features of glacial erosion and describe the magnitude of this form of erosion.	Explain why glaciers are so effective in abrading the bedrock. Describe and list the effects of valley glaciers on the earth's surface. Discuss why the soil is so thin north of the Ohio and Mississippi Rivers. @ Students could report on the Matterhorn - a glacially-carved mountain. *Skillcard No. 28 on glaciers demonstrates why glaciers are able to wear away hard rock. Students could bring pictures showing glacial erosion. These pictures could be of Yellowstone, the Great Lakes, the lakes of Minnesota, the national parks of Western United States. From these pictures they could try to identify different features of glacial erosion.

PERFORMANCE OBJECTIVES	SUGGESTED ACTIVITIES
The student will --	Have students do the activity "Changes Caused by Glaciers."
Identify types of glacial deposits and explain how they were formed.	To demonstrate the process of how icebergs deposit their load, have students mix several grams of sand in a plastic container filled with water. Have them place the plastic container in a freezer until the water freezes. Have students place the block of ice in an aquarium filled with warm water. They should notice that as the ice melts, the home "iceberg" deposits its load on the aquarium bottom. Have students explain how this demonstrates what happens when a real iceberg melts in the ocean. *Skillcard No. 29 on icebergs is a very simple demonstration that shows the students how ice floats with about 9/10 of its volume below the water. There are good books on icebergs, the patrols (shipping lanes), and the Titanic. Explain the origin of Kettle Lakes. Students could do exercise 14:1, Glacial Landscape Features, page 69 of the Review Guide. On page 273 is an experiment showing how a glacier affects the surface over which it moves.
Describe the relationsip between sea level and glaciation.	List the cities that would be covered by the sea if all the present glaciers melted. Students should do the activity on page 97 of the Lab Manual - Glaciation and Sea Level. In this activity students will interpret the effects of changing sea levels on Galveston and Freeport, Texas.
Discover that glaciers leave behind very good clues and that from these clues the Ice Age has been studied in great detail and theories of its origin have been developed.	Have the students study the drainage pattern of the Great Lakes before and after the Ice Age. Have the students show on a map of North America the area covered by the last glacial period. Film: Evidence for the Ice Age

PERFORMANCE OBJECTIVES	SUGGESTED ACTIVITIES
The student will --	Have students discuss the idea of towing icebergs to ports as supplies of fresh water. Discuss what effect would be felt if all polar ice melted and raised sea level 30-40 meters. Have students discuss the most recent research into the cause of ice ages. Have students do 14:2 - Tilting of the Earth, page 70 of the Review Guide. Also Glacial Theories on page 71. For the study of Chapter 17 (Land Forms) you may wish to send for the topographic maps instead of trying to use those from the book because the reduction in size makes it difficult to read many of the figures. Write to: U.S. Geological Survey Washington, D.C. 20242 for the topographical maps published. Raised relief maps prepared from these topographical maps may be ordered through: Hubbard Scientific Company P.O. Box 104 Northbrook, IL 60062

CHANGES CAUSED BY GLACIERS

Problem: How could glaciers have caused changes in the surface of the earth?

Materials: Plastic dishpan, ruler, ice cubes, sand

Procedure:

1. Pour enough sand into the dishpan to make a layer about 15 centimeters (6 inches) thick. The sand will represent the surface of the earth.

2. Place 3 or 4 ice cubes in a row on the surface of the sand. The cubes will represent the moving front edge of a glacier. Use the side of a ruler or a pencil to slowly push the ice cubes a short distance over the surface of the sand. Observe what happens along the front edge of the row of ice cubes. Let the ice cubes remain where they are.

3. In another part of the dishpan, arrange 8 to 12 ice cubes in two rows with a space of about 2 centimeters (3/4 inch) between rows. The rows do not have to be straight. Cover the ice cubes and space between them with sand.

4. In another part of the dishpan, bury 3 or 4 ice cubes in the sand. Bury each ice cube at a different depth in the sand. Level the sand above these ice cubes.

5. Set the dishpan in a place where it will not be disturbed and allow the ice cubes to melt.

6. After the ice cubes have melted, observe the surface of the sand in the dishpan.

Results and conclusion:

1. What happened to the sand when you pushed a row of ice cubes over the surface?

2. What surface feature thought to have been formed by glaciers did this seem to resemble?

3. What happened to the sand when the two rows of ice cubes melted?

4. What surface features thought to have been formed by glaciers did this seem to resemble?

5. What happened to the sand when the buried ice cubes melted?

6. What surface features thought to have been formed by glaciers did this seem to resemble?

UNIT V

EARTH'S INTERNAL PROCESSES

CHAPTER 15: EARTHQUAKES

(Time Allotment: 4 days - One Semester)
8 days - Two Semesters)

Major Concepts to be Taught

Internal forces cause earthquakes
Formation of rock structures
Seismic studies give clues about the Earth's interior

Essential Learner Outcome

Describe how a volcano and earthquake can change the surface of the Earth.

Instructional Objectives

The student should be able to -

B . Describe the difference between tension, compression, shearing, and buoyancy
e . Determine that rocks are subject to breaking because of internal forces and recognize how these internal forces shape the Earth's surface
B . Explain how earthquakes occur and describe the instrument used to measure the intensity of an earthquake
. Differentiate between L, P, and S waves and explain how earthquake waves are used to gain information about the Earth's interior

Assessment Guidelines

The student will

. Name four internal forces.
. Using arrows, show how stress is applied during compression, tension, and shearing.
. Define buoyancy, isostasy.
. Demonstrate buoyancy and compare the results with how the balance between different parts of the earth's crust is maintained.
. Define or describe three of these terms:

structure	fault	anticlines
fracture	folds	synclines

. Name the three types of earthquake waves.
. Distinguish between the focus and epicenter.
. Explain what the absence of S wave tell about the Earth's interior.
. Describe the mohorovicic continuity.

PERFORMANCE OBJECTIVES	SUGGESTED ACTIVITIES
The student will -- Describe the difference between tension, compression, shearing and buoyancy	Have students do Skillcard No. 25 - Isostasy. A simple activity to demonstrate how large mountain ranges "float" on the mantle. Have students do "Forces Which Affect Rocks." Students could do the reading skills activities and the tension activity included in this guide. Have students do the experiment on page 46 of the Activity Book which demonstrates the effects of stress on rock. Students should do the experiment on page 294 of the textbook. This experiment demonstrates how buoyancy keeps a balance between different parts of the earth's crust. On pages 127-131 of the Activity Book, are two additional activities on isostasy and buoyancy. These require minimal materials and are easy to complete. The problems to be solved in these activities are: 1) How is block faulting related to isostasy? 2) How is isostasy related to buoyancy? Have students diagram tension, compression and shearing forces.
e Determine that rocks are subject to breaking because of internal forces and recognize how these internal forces shape the earth's surface.	The activity on page 287 has the students make sedimentary layers and then apply stress to form folds and faults. This is an excellent activity. Lab No. 45 - Using a Clinometer. Define stucture, fractures, faults, folds. Use transparencies to show these features. Have students do the activity "The Crust Moves." In this activity students will make models of syncline, anticline, reverse fault, and normal fault. @ Have students make models demonstrating the four different classifications on faults. See page 887. Do the Extension to Activity 15-2, page 120 of the Activity Book.

PERFORMANCE OBJECTIVES	SUGGESTED ACTIVITIES
The student will --	Students could do exercise 15:1 - Rock Structures, page 73 of the Review Guide.
Explain how earthquakes occur and describe the instrument used to measure the intensity of an earthquake.	Have students bring to class newspaper or magazine articles about recent earthquakes around the world. Discuss the intensity and damage caused by earthquake. @ Have students to find out about earthquakes that were experienced in Texas. Students could research and report on major earthquakes of the past few hundred years. Students should do Lab No. 46 - Earthquakes, pages 105-108 of the Lab Manual. In this activity students will study the occurrence of earthquakes in the United States and determine which areas are earthquake prone. Students could report on one of the following: a. Mid-continent earthquake b. New Madrid fault earthquakes c. San Andreas fault in California Have students construct a seismograph which will record local disturbances. See page 121 of the Activity Book for details. Students could reporet on Charles F. Richter and how he developed his scale. Students could do the activity Volcanoes, Earthquakes and Earth's Interior.
Differentiate between L, P, and S waves and explain how earthquake waves are used to gain information about the Earth's interior.	Have students to observe the seismograph vibrations which are recorded as a result of heavy equipment movement and other phenomena which produce vibrations. Have students demonstrate the movements of earthquake vibrations similar to P waves with a slinky toy. This activity is found on page 114 of the Activity Book.

PERFORMANCE OBJECTIVES	SUGGESTED ACTIVITIES
The student will --	Students could demonstrate S waves by supporting one end of a rope and applying a quick up and down motion to the other end. @ Have students do extensions to the activity on pages 126-127 of the Activity Book. Have students do Lab No. 47 - Locating an Earthquake. In this activity students will compute the location of the epicenter of an earthquake. This activity is on pages 109-112 of the Lab Manual. Students could do exercise 15:2 Probing Earth's Interior, pages 74 of the Review Guide. Students will use a graph to answer questions about earthquake waves on page 75 of the Review Guide. Have students read Focus on Frontiers, page 298 of the textbook. Students could also do People and Earthquakes - exercise 15:4, pages 576-577 of the Review Guide.

FORCES WHICH AFFECT ROCKS

Problem: Can you determine three types of forces which affect rocks?

1. Measure the length of a thick rubber band without stretching it. Now stretch it until the band breaks and measure its length.

2. Stand a piece of wood screen molding on end and brace it so it cannot move. Try to bend the molding in an arc. Now grasp an end of the molding in each hand and break it.

3. Place two wooden blocks on a table so they touch one another. Push one block in one direction and the other block in the opposite direction so they slide past one another.

Does stretching and breaking of the rubber band change its length? What force breaks the band? What kind of force are you applying to the molding? Describe the sensation in your hands to the blocks? What is the relationship between the rubber band and faulting?

CRUSTAL MOVEMENT

READING SKILLS ACTIVITIES

I. DIRECTIONS: Fill in the blank. Use your own paper.

Diastrophism is a movement of the earth's crust. Tension is a force that causes _____.

MAIN IDEA: Tension is one of the internal forces that causes _____ to move.

II. DIRECTIONS: Complete this cause and effect relationship. Use your own paper.

CAUSE: A tremendous force pulls on opposite sides of a huge rock.

EFFECT: _____

III. DIRECTIONS: Complete each sentence by selecting a word from the word box that makes the statement true. Use your own paper.

crustal movement	pulling
scientists	tension
opposite	diastrophism

1. Tension is a _____ force exerted upon a body.
2. The pulling force of tension acts in _____ directions.
3. If the pulling force of _____ is great enough, it will pull a body apart.
4. Folded, twisted or broken rocks tell _____ the direction of crustal movement.
5. Tension is one example of _____.

(Answers may vary.)

CRUSTAL MOVEMENT

"Tension"

In this activity you will demonstrate the force of tension. When this force becomes too great, a body will lose its elasticity. When stretched beyond its limit of elasticity, an object will break or pull apart.

Materials needed: slinky toy (or rubber band or foam rubber)

PROCEDURE:

- Measure the length of the slinky toy and record the measurements.
- Pull on one end of the slinky while another student is pulling on the opposite end. This creates tension in the slinky. Let another student measure its length.
- See if the slinky will return to its original shape.
- Repeat steps two and three, but apply more force each time. Record your result.

CONCLUSION:

1. Did you and your partner apply any force to the slinky?
2. What kind of force did you apply?
3. How far did you have to pull the slinky before it would not return to its original shape?
4. What do you think could happen if the tension becomes too great?

There are forces in the earth that are pulling in opposite directions on large masses of land. We call these forces tension. What could happen to large land masses if the force became too great?

CRUSTAL MOVEMENT

I. MAIN IDEA: Compression is a squeezing force that causes _____.

(Answers may vary.)

II. DIRECTIONS: Complete this cause and effect relationship.

CAUSE: Tremendous force is applied upon a body from direct opposite sides.

EFFECT: _____

_____

III. DIRECTIONS: Complete the following sentences by selecting a word from the word box that makes each statement true. Use your own paper.

bend	diastrophism	break
opposite	crustal movement	squeezing force
pull		squeeze

1. Compression is a _____.
2. Compression and tension act upon a body in _____ directions.
3. Forces of compression _____ and forces of tension _____.
4. Forces of compression, if great enough, will cause a body to _____ or _____.

CRUSTAL MOVEMENT

I. MAIN IDEA: A shearing force from opposite sides, but not directly opposite exerted upon a body causes it to _____ or _____.

II. DIRECTIONS: Complete this cause and effect relationship. Use your own paper.

CAUSE: _____

EFFECT: A huge rock twists or is torn.

III. DIRECTIONS: Complete the following sentences with a word from the word box to make each statement true. Use your own paper.

crustal movement	tension
force	shearing forces
shearing	diastrophism
opposite	

1. A shearing force is a pulling _____.
2. Shearing is like tension because it is a _____, and acts upon _____ sides of a body.
3. Shearing and tension are not alike because _____ pulls on direct opposite sides of a body and _____ pulls on opposite sides, but not directly opposite.
4. _____ _____ cause bodies to be twisted or torn.
5. Shearing causes _____.

THE CRUST MOVES

LAB ACTIVITY:

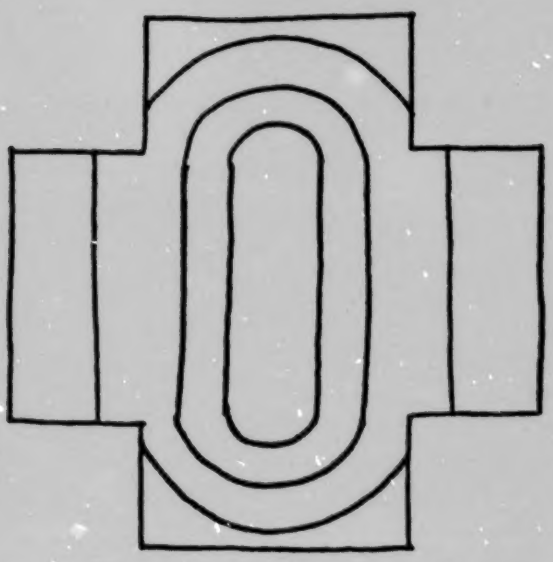
Have students color each of the layers on the four drawings in such a way that when the drawings are cut out and folded, the color of the layers will match.

The layers can be labeled on the colored side and the definitions can be written on the back, if you wish.

When the students cut out the figures, fold, and attach the flaps, these will become three-dimensional models.

You may wish to offer extra credit to students who make larger models of posterboard or some other flat or solid material. This idea could be expanded and enriched in many ways, even to the extent of a "science fair" exhibit.

SYNCLINE



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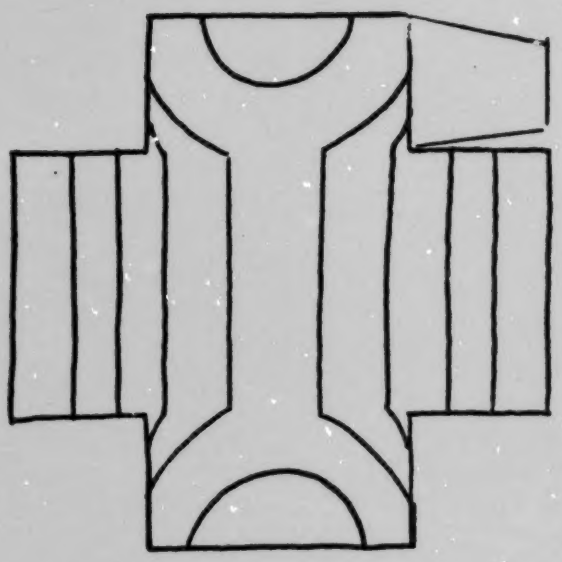

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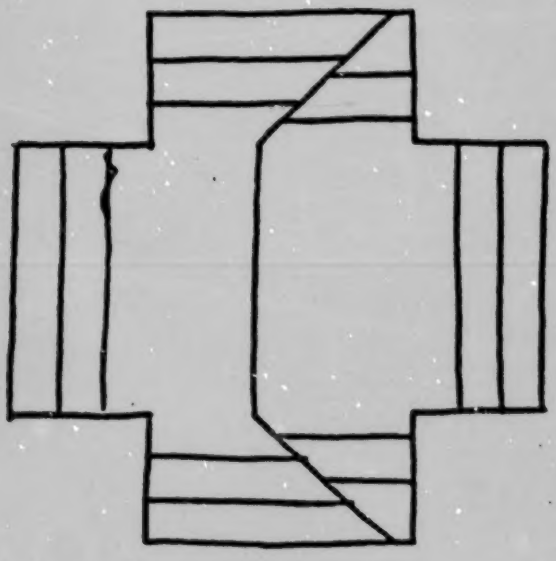
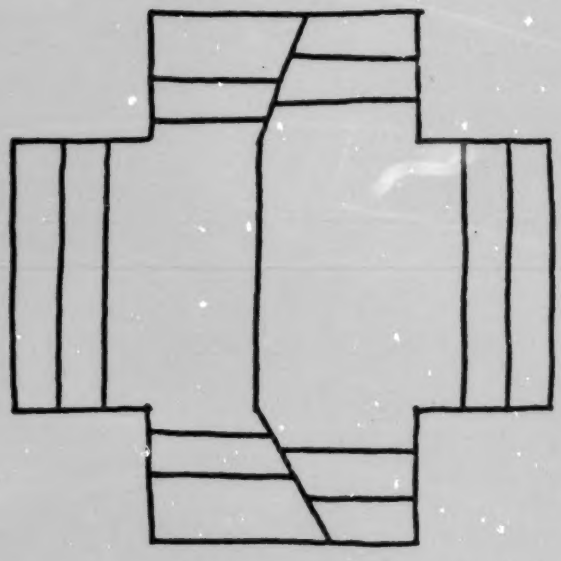
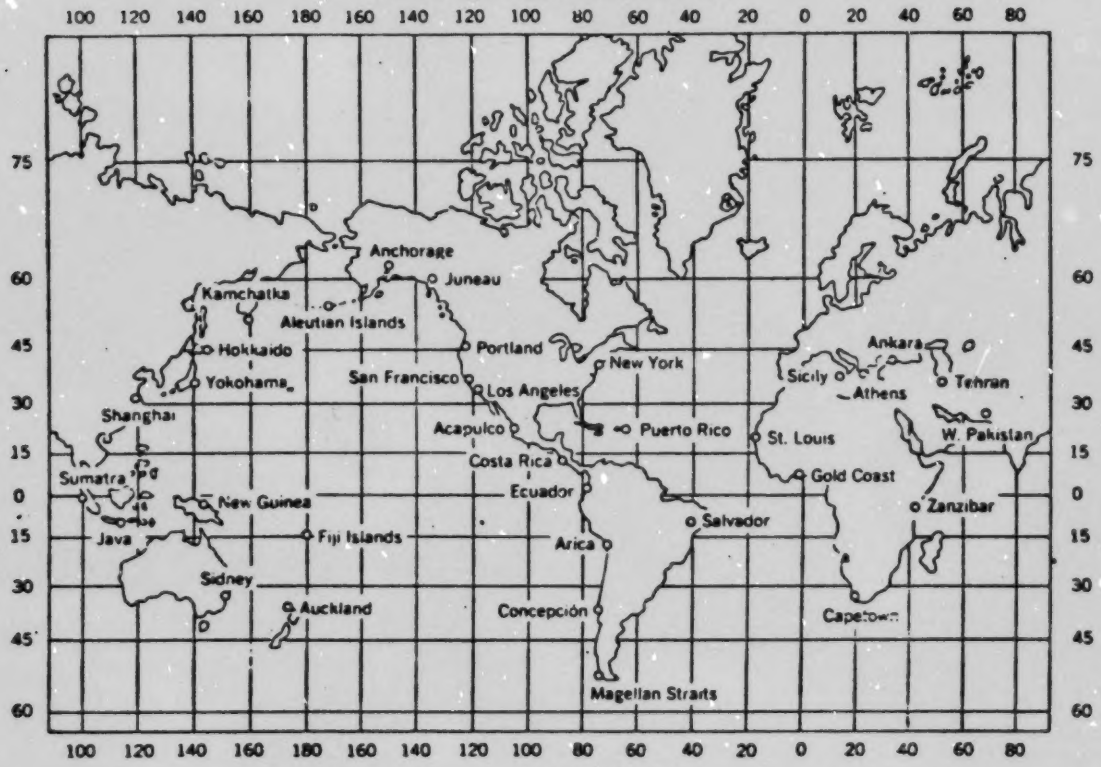


NORMAL FAULT



Circle of Fire Activity



1. The places where earthquakes have occurred most frequently are listed below. these places are shown in the map of the world above. Locate each place on the map, and darken the circle near each place.

Acapulco	Auckland	Hokkaido	New Guinea	Shanghai
Aleutian Islands	Concepcion	Java	Pakistan	Sicily
Anchorage	Costa Rica	Juneau	Portland	Sumatra
Ankara	Ecuador	Kamchatka	Puerto Rico	Tehran
Arica	Fiji Islands	Magellan Straits	San Francisco	Yokohama
Athens				

2. Between the meridians of 100°E and 60°W longitude, draw a line connecting the circles you have filled in.

   Describe any pattern or patterns you see in this region of the world. _____

   _____

   _____

3. Between the meridians of 80°W and 80°E longitude, draw similar lines connecting the circles you have filled in.

   In what ways, if any, do the patterns in this region differ from the pattern(s) in activity 2? _____

   _____

4. Using a map of the world as a guide, place an X on the map where the following volcanoes are located.

Fujiyama (Japan)	Taal (Philippines)	Popcatepetl (Mexico)
Mauna Kea (Hawaii)	Krakatoa (Java)	Mt. Shasta (California)
Mt. Pelee (Martinique)	Paricutin (Mexico)	Vesuvius (Italy)
Mt. Ranier (Washington)		

What relation do you observe between the location of these volcanoes and earthquake zones? Explain. _____

_____

What can you conclude concerning the geologic features in certain parts of the world and the occurrence of earthquakes? _____

_____

_____

_____

CHAPTER 16: PLATE TECTONICS THEORY

(Suggested Time: 2 days - One Semester)
8 days - Two Semesters)

Major Concepts to be Taught

Evidence of Continental Drift
Development of the Plate Tectonics Theory
Importance of the Mid-Ocean Ridge
Divergent and Convergent Boundaries

Essential Learner Outcomes

The student will -

Describe how a volcano and earthquake can change the surface of the earth.

Instructional Objectives

The student should be able to -

e . Cite evidence of the movement of the earth's crust.
. Discuss the importance of the mid-ocean ridge.
. Discuss the supporting evidence for continental drift.
e . Discuss the plate tectonics theory and its relation to continental drift and seafloor spreading.

Assessment Guidelines

The student will -

. Tell when youthful mountain chains are located.
. Describe the mid-ocean ridge.
. Name two main features of the ocean basin.
. Give the name for the single continent described in the continental drift theory.
. List evidence that supports the continental drift theory.
. Name the instrument which allowed scientists to map the ocean floor.
. Explain where new ocean floor is forming.
. Conduct an activity to determine why blocks of earth's crust change positions
. Define convergent and divergent plate boundaries.
. Give an example of a divergent boundary.
. Identify where convergent boundaries are found.
. Describe the subduction zone and relate it to volcanic eruptions and formation of volcanic islands.

Materials

Textbook: Focus on Earth Science, pages 302-321

Earth Science Skillcards:
No. 22 - Earth in Space - Magnetic Field, Part III, for Section 16:3, page 308

Lab Manual: "Earth Science - A Learning Strategy for the Laboratory"
No. 48 - Earth's Magnetism
No. 49 - Continental Drift

Earth Science Activity-Centered Program, Teacher's Guide
Page 133, Teacher Demonstration

Focus on Earth Science Review and Reinforcement Guide
16:1 - History of Plate Tectonics Theory
16:2 - Locating Plate Boundaries
16:3 - Plate Boundaries

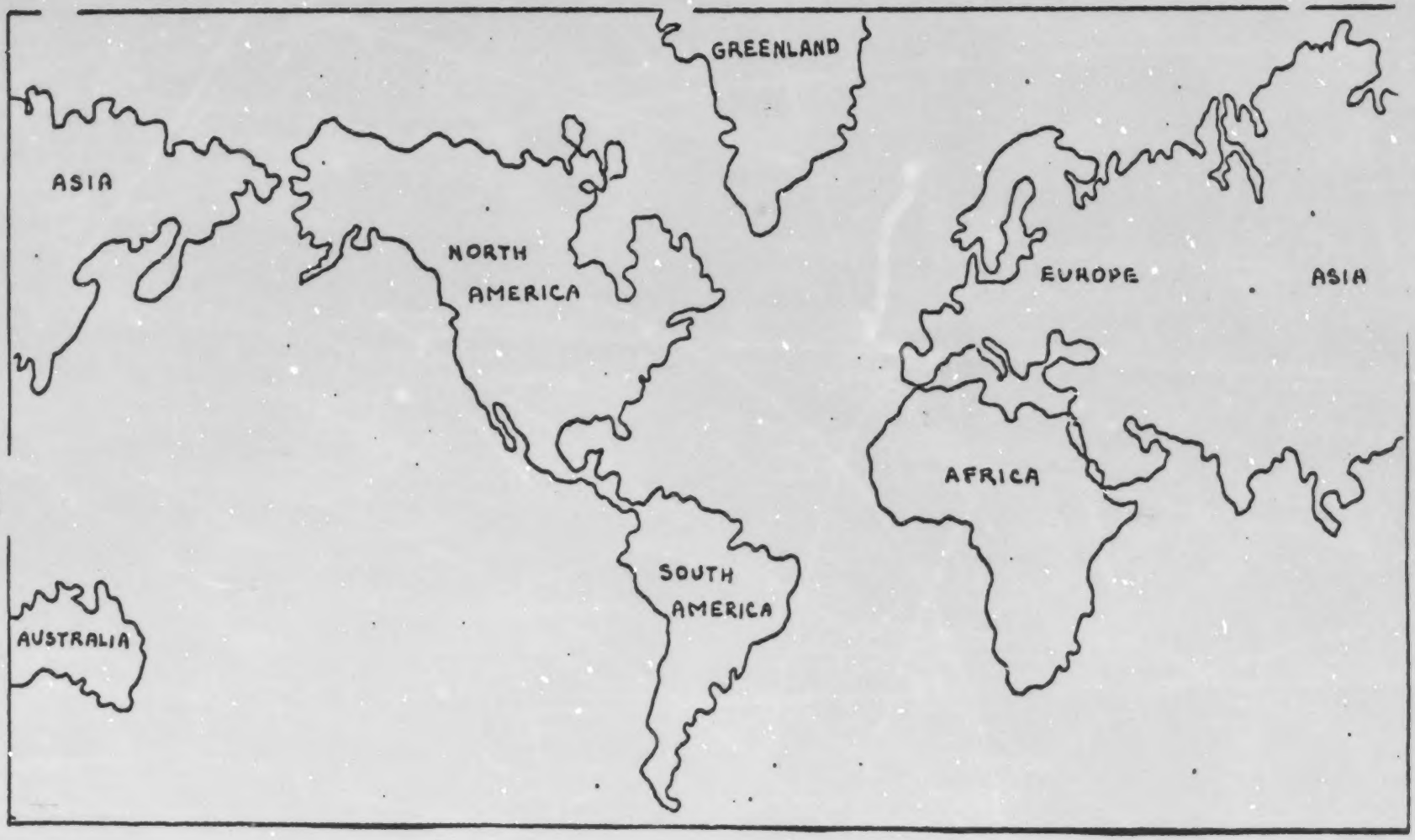
Additional Suggestions:
- A, B, C, exercises pages 319-321
- Points to Remember, page 319
- Words to Use, page 319
- How and Why, page 321
- More Ideas to Explore, page 321

Films:
M5696 - Heartbeat of a Volcano (1970) 21 min. (stages of volcanic activity)
5679 - Fire Mounain (1970) 9 min. (Kilauea Volcano in Hawaii)
5200 - Stromboli - A Living Volcano
M5241 - Succession of Lava

PERFORMANCE OBJECTIVES	SUGGESTED ACTIVITIES
The student will -- Cite evidence of the movement of the earth's crust.	Have students locate major mountain chains, using a world map. Himalayas 75E 30N Alps 10E 45N Atlas 0 30N Appalachian 80W 40N Arides 70W 30S Coast 120W 40N Plot past and present volcanoes on a world map and name where the volcanoes are located in the United States. Hand out copies of chart on "active and extinct volcanoes." Have students do "Ring of Fire" activity in this guide. Have students do research on recent volcanic activity in these areas. Read about eruptions of Mt. St. Helens and make an oral report to the class. Using reference materials, have students put a dot on a map for each volcano that has displayed activity within the last year for which information is available. Have them place different colored dots on the maps for earthquakes that occurred during the same period.
Discuss the importance of the mid-ocean ridge.	Review major features of ocean floor as discussed in Chapter 10. Name the two main features of the ocean basin. Use the map in this guide to draw in the mid-ocean ridge, the fracture zones, and the ocean trenches. @ If students did not do the activity for Chapter 10, have them complete it at this point. Use the read-from selected soundings taken by a ship and the Depth/Distance chart to draw a profile to represent the sea floor of the Atlantic Ocean along the parallel 39° N. See the "Ocean Basin" activity in this guide.

PERFORMANCE OBJECTIVES	SUGGESTED ACTIVITIES
The student will --	Explain what causes the ocean floor to increase in size and the importance of the mid-ocean ridge. Have students use refernce materials in the library to locate major trenches in the Atlantic, Pacific, and Indian Oceans. Have them place their data in a chart. Have students use different colors of modeling clay to reconstruct a model of the ocean floor showing mid-ocean ridges, and trenches next to continental areas.
Discuss the supporting evidence for continental drift.	Have students do a library investigation to find out about Alfred Wegener and write a short report on some of his major accomplishments, his expeditions to Greenland, why his theory of continental drift criticized. Students should do Skillcard No. 22 - Magnetic Field, Part II. Have students do Lab. No. 49 - Continental Drift. A similar activity is to have students trace outlines of the continents from a globe and then cut around the outlines of the seven continents. Have them try to fit the continents together to form a large supercontinent similar in appearance to Pangaea. Students should do Lab No. 48 - Earth's Magnetism, page 113 of the Lab Manual. Make a transparency or hand out copies of diagrams in the activity "Continental Drift Theory." Have a student label Africa, South America, and Antarctica on the diagram of the Earth Today. Ask students how Lystrosaurus could migrate from one continent to another across an ocean.
Discuss the plate tectonics theory and its relation to continental drift and sea-floor spreading.	Students should do the activity on page 311. This activity demonstrates the influence of convection currents on objects floating on a liquid. Diagram the convection currents of the mantle.

PERFORMANCE OBJECTIVES	SUGGESTED ACTIVITIES
The student will --	Have students observe figure 16-9 on page 312 and list the lithosphere plates. Describe the asthenosphere and how the crustal materials float on the mantle. Have students differentiate between zones of convergence and zones of divergence. Referring to a map have students locate areas of convergence and divergence. Have interested students make a large classroom poster showing the earth's crustal plates. Demonstrate volcanic activity. See Teacher Demonstration, page 133 of the Activity Book. Have students demonstrate that heat from below the crust sends matter to the surface and relate this activity to the process of seafloor spreading. This can be demonstrated by doing the activity on page 314 of the textbook. Have students do the following exercise in the Review Guide, pages 79-82. a. 16:1 - History of Plate Tectonics Theory 16:2 - Locating Plate Boundaries 16:3 - Plate Boundaries @ Have students use reference materials to determine the direction of Crustal Plate movements and predict the future shape of the earth's landmasses. Have students read Focus on Frontiers, page 318 of the textbook. @ Have students do More Ideas to Explore, No. 2, page 321 of the textbook. Have students find out about the origin of the Hawaiian Islands, Iceland and the Aleutian Islands and write a brief report with diagrams explaining what they have learned.



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Use the map to draw in the mid-ocean ridge, the fracture zones, and the ocean trenches.
For extra credit draw in the recent earthquake epicenters.

46

ACTIVE AND EXTINCT VOLCANOES AROUND THE WORLD

Volcano	*Latitude*	*Longitude*	*Volcano*	*Latitude*	*Longitude*
Reventador	0.1° south	77.7° west	Krakatoa	6.1° south	105.4° east
Ubinas	16.2° south	70.8° west	Barren I.	12.2° north	93.8° east
Maipo	34.1° south	69.9° west	Santorini	36.4° north	25.4° east
Mt. Burney	52.3° south	73.4° west	Vesuvius	40.8° north	14.4° east
São Jorge I.	38.6° north	28.0° west	Lanzarote I.	29.0° north	13.7° east
Katla	63.6° north	18.9° west	Paramushiro I.	50.3° north	155.3° east
Beerenberg	71.0° north	8.0° west	Katmai	58.3° north	155.0° west
Erta-Ale	13.6° north	40.6° east	Mt. Rainier	46.9° north	121.8° west
Niragongo	1.5° south	29.2° east	Lassen	40.5° north	121.3° west
Kartala	11.9° south	43.3° east	Tres Virgènes	27.5° north	112.7° west
Mauna Loa	19.5° north	155.9° west	Paricutin	19.5° north	102.1° west
Erebus	77.5° south	168.0° east	Poás	10.2° north	84.2° west
Pagan I.	18.1° north	145.8° east	Kanaga	51.9° north	177.2° west
Chyulu Hills	2.9° south	38.1° east	Brimstone I.	30.2° north	178.9° east
Saishuto I.	33.4° north	126.5° east	Late I.	18.8° north	174.6° west
Mayon, Luzon	13.3° north	123.7° east	Hunter I.	22.3° north	172.1° east
Makian	0.3° north	127.4° east	Tinakula	10.4° north	165.8° east
Lokon	1.4° north	124.8° east	Pago	5.6° north	150.6° east
Seroea	6.3° south	130.0° east	Fuji	35.4° north	138.2° east
Tambora	8.2° south	118.0° east			

RING OF FIRE

Problem: How are volcanoes and earthquakes related to plate tectonics?

Materials: An outline map of the world
Colored pencils
Paper and regular pencil

Procedure:

1. Use the circle of fire map and locate places where volcanoes and earthquakes most frequently occur.

2. Connect the lines (using a red pencil) to form the ring of fire. Use the outline of the world map to draw in the lithosphere plate boundaries for the seven major plates and the Arabian and Caribbean plates. Label each plate with a yellow pencil; draw in the mid-Atlantic ridge.

3. Using a brown pencil, draw small arrows to indicate the movement of the plates. What is the relationship of the "Ring of Fire" to the Pacific plate? How does this relationship explain why so many volcanoes are found in this area? How can the occurrence of so many earthquakes in this region be explained?

4. Based on information in Chapter 17 and on your map, answer the following questions: Is the Atlantic Ocean getting larger or smaller? Is the Red Sea getting larger or smaller? Are New York and Denver moving closer together, farther apart, or staying the same distance from each other? Are the states of Hawaii and Alaska moving closer together or farther apart? Is the Pacific Ocean getting larger or smaller? Explain your answers.

VOLCANOES, EARTHQUAKES, AND EARTH'S INTERIOR

The article which is reproduced on the next two pages appeared in many newspapers on May 19, 1980. The Associated Press has granted permission for us to reproduce them.

Questions

1. What happened to the height of Mount St. Helens?

2. List some of the ways in which the eruption changed the landscape of the area.

St. Helens erupts; at least 8 killed

VANCOUVER, Wash. (AP) — Mount St. Helens blew its top Sunday with a blast felt 200 miles away, belching ash and hot gas which blotted out the sun for more than 450 miles and killing at least eight people. Mudflows and floods destroyed bridges and forced evacuation of about 2,000 people.

At least three people were missing and scenic Spirit Lake at the base of the mountain disappeared under mud and rock flows.

The eruption at 10:39 a.m. CDT shot smoke and ash nine miles into the sky. A spectacular lightning storm in the rising plume started numerous forest fires. By evening the fires covered 3,000 acres on the mountain. There were no immediate reports of lava.

In Walla Walla, 160 miles to the east, drifting ash made the sky so dark that automatic street lights went on and by evening more than a foot of ash had accumulated at Camp Baker, 15 miles west of the volcano. Ash was also reported falling in parts of Idaho, more than 200 miles downwind.

The eruption was visible here, more than 50 miles to the southwest, and the explosion was felt in Vancouver, B.C., more than 200 miles to the north.

By Sunday evening, the once-snow-covered 9,677-foot peak was reduced to about 9,100 feet, said U.S. Geological Survey spokesman Worner Gerhard. Its crater was a half-mile across.

The bodies of two people found at a Weyerhaeuser logging camp near the mountain were flown to Kelso, Wash., by an Air Force Reserve helicopter, said Air Force Lt. D.E. Schroeder. They were killed by heat, Schroeder said, but no more details were immediately available.

Five other people were reported to have been killed, two in a mudslide, said Nolan Lewis, director of emergency services for Cowlitz County.

The bodies of two of the victims were ...ted in a car about 1.5 miles east of Camp ...er, which is about 15 miles west of the ...olcano, said Air Force Reserve Capt. Robert J. Wead.

"These people were fried with the heat," Wead said. "Trees and all the vegetation was laid out flat — singed, burned, steaming, sizzling — a terrible-looking thing."

Turn to St. Helens on Page 2

—Associated Press Laserphoto

RECORD ERUPTION... Mount St. Helens in its most violent action yet

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St. Helens erupts; 7 killed

Continued from page 1

"The devastation on the mountain side is incredible," said Schroeder. "Trees are knocked down, animals are standing around in shock, covered with ash."

Mudflows entered both forks of the Toutle River on the north flank of the mountain in Washington's southwestern corner, swelling the river to three times its normal width, aerial observers said.

A brown wall of water reported as high as 20 feet in places swept down the Toutle with debris and logs, destroying several bridges on the Spirit Lake Highway, said the Washington State Patrol.

The flood was followed by a mile-long log jam that was forced down the Toutle and into the larger Cowlitz River, where thousands of people lined the banks to watch.

About 2,000 people were evacuated from the town of Toutle and nearby low-lying regions, 30 miles northwest of the mountain. Most people living closer to the mountain had left weeks ago.

The U.S. Forest Service recommended the evacuation of the Kalama River valley southwest of the mountain, said spokesman Phil Cogan.

There was no word on the whereabouts of Harry Truman, a crusty 84-year-old who had refused to leave his Spirit Lake resort, on the headwaters of the Toutle at the foot of the mountain. "We can only fear the worst," said Jim Hall of the state Department of Emergency Services.

Wead said U.S. Forest Service pilots reported the Spirit Lake area, once a popular recreation area, was gone. He said there was no lake, no trees, and even the profile of surrounding hills had been altered by mud and rock slides. Earlier, pilots had reported the lake was a "boiling mass emitting gas" as it was heated by hot debris.

Two scientists were believed to have been at a USGS camp at about the 5,000-foot level of the mountain, but the crew of an Air Force helicopter flew over the USGS camp and reported no people in sight, said Maj. Bill Hewes of the Air Force Reserve 304th Rescue and Recovery Squad of Portland, Ore. The camp was covered by four to six feet of debris and a buried vehicle was spotted, he said.

A mudflow also reached from the south side of the mountain to the Lewis River, which was reported rising. There are three hydroelectric dams on the river and utility officials had drawn down the reservoirs in anticipation. The water level of the Swift reservoir was raised two feet by the mud, said Pacific Power & Light spokesman Leonard Bacon.

"The air is so full of smoke and pumice stone that a person would not live outside," said James Lanterman, 60, a ham radio operator who was broadcasting from a mobile home in Randle, about 20 miles northeast of the mountain. "I was thinking of evacuating but I didn't think I could make it, so I'm staying inside."

"It's just like midnight," Sgt. Larry Gamache of the Yakima County sheriff's office said late in the afternoon at Yakima, about 100 miles downwind.

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QUESTIONS:

Article about the volcano

1. On what date did Mount St. Helens erupt? _____
2. What has the eruption done to the shape of the mountain? _____

_____

3. When this article was written, had the volcano erupted any lava? _____
4. Do the people want to admit that the volcano is active? _____

_____

5. Why do you think the people feel the way they do? _____

_____

Article about the earthquake

1. In what state are Seattle and Tacoma located? _____
2. In what state is Mount St. Helens located? _____
3. Did this particular earthquake cause any injuries? _____
4. What is the name of the scale used to measure the ground motion of earthquake?

_____

5. Is the Northwestern United States included in the so-called "Ring of Fire?"

_____

These two articles appeared in many newspapers on April 28, 1980. The Associated Press has granted permission for us to reproduce them.

Volcano a bit tipsy with action

VANCOUVER, Wash. (AP) — Mount St. Helens has become slightly tipsy with all its recent volcanic activity, a U.S. Geological Survey scientist said Sunday.

Measurements of ground deformation at the timberline on the 9,677-foot peak showed the mountain tilted a little north in recent days, said geologist Bob Christiansen.

Christiansen said scientists had no exact idea what causes the tilting or what it might portend.

Activity at the volcano's summit remained at a low level, as it has for the past week, Christiansen said. "Eruptive bursts of steam and ash have been too small to reach above the crater." Yet vents in the summit crater continuously emit steam.

The volcano in southwestern Washington state erupted March 23. Ash eruptions, thousands of feet into the air, continued for several weeks. No lava has erupted.

"I say activity has remained at a low level, but I'm not saying the mountain has stopped volcanic action," Christiansen said. "The tilt on the north side of the mountain shows that.

"People don't want to admit the mountain is still active — and dangerous — unless it's a little bit grander each day. Seismic activity also shows the mountain hasn't quieted down," Christiansen said.

Quake rocks Washington

SEATTLE (AP) — The countryside between Seattle and Tacoma was rattled by a minor earthquake during the weekend, but no damage or injuries were reported.

University of Washington seismologists said the quake struck just after 10 p.m. Saturday. The tremor registered 3.2 on the Richter scale, according to the U.S. Geological Survey's National Earthquake Information Service in Golden, Colo.

The Richter scale is a measure of ground motion as recorded on seismographs. An earthquake of 3.5 on the Richter scale can cause slight damage in the local area.

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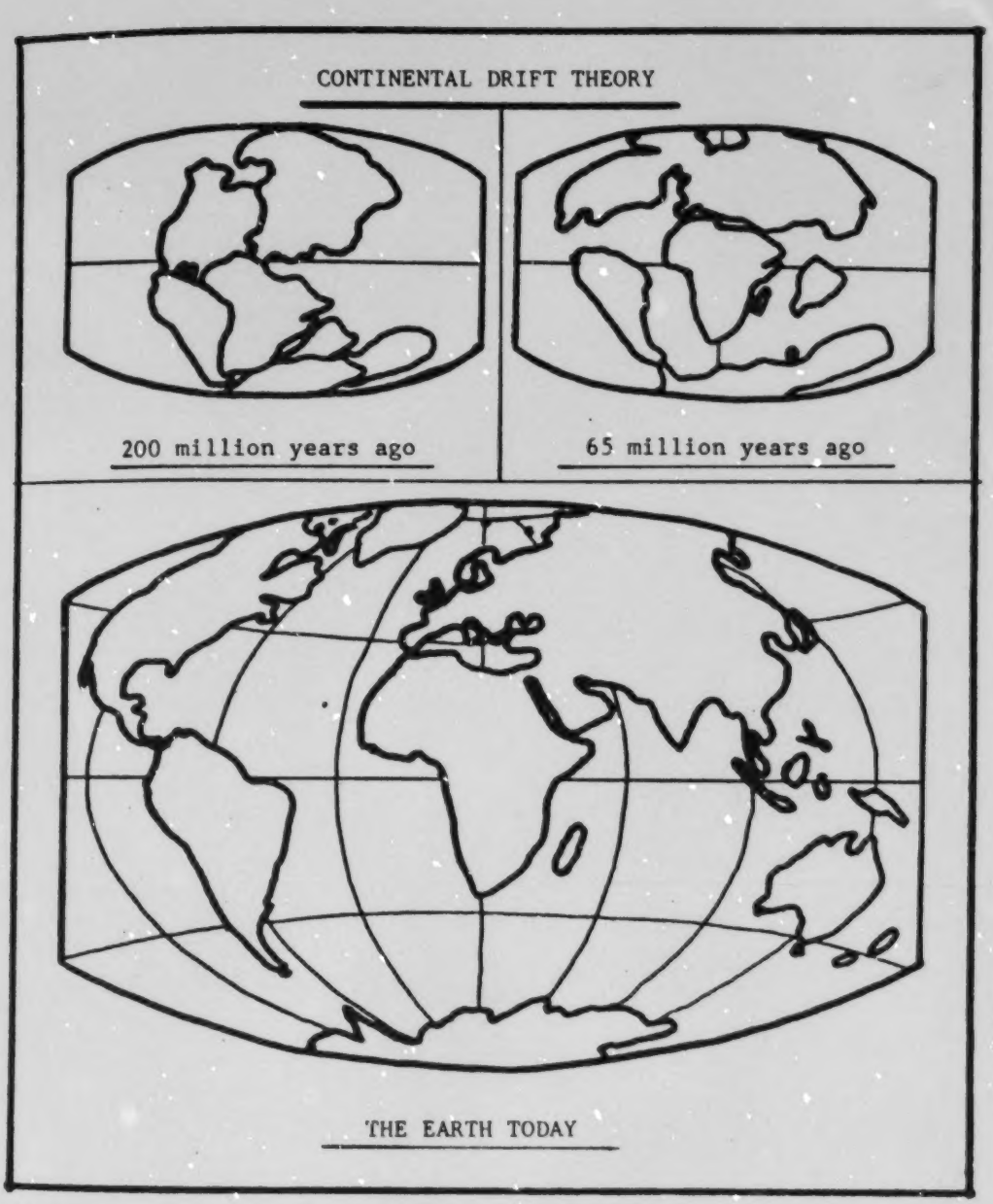
CRUSTAL MOVEMENT

ACTIVITY 7



At the edges of the plates, many changes are taking place, while their inner most regions remain stable.

CHAPTER 17: LANDFORMS

(SUGGESTED TIME: 4 days - One Semester)
7 days - Two Semesters)

Major Concepts to be Taught

Formation of mountains, plateaus, and plains
Formation of igneous rock bodies
Study of landforms by use of topographic maps

Essential Learner Outcomes

The student will -

- Describe one way each that wind, moving water, and freezing water (orice) can change the surface of the earth.
- Describe how a volcano and an earthquake can change the surface of the earth.

Instructional Objectives

The student should be able to -

- e . Recognize that mountains can be classified as structural, volcanic, or dissected according to how they were formed.
- e . Identify igneous rock formations, plains, and plateaus, and give examples of each.
- . Use a topographical map to determine landforms and climates.

Assessment Guidelines

The student will -

- . describe at least three landforms observed from pictures.
- . list the three basic types of landscapes.
- . distinguish between mountains and hills.
- . differentiate between the formation of structural mountains and dissected mountains.
- . identify the four types of volcanoes.
- . name five rock bodies, describe two of these, and how they are formed.
- . describe the difference between plains and plateaus.
- . collect or draw pictures of different landforms.
- . name and describe four stream patterns.
- . identify the following, using a topographic map:
  - a. kinds of climates
  - b. landforms
  - c. drainage features

Materials

Textbook: Focus on Earth Science, pages 322-349

Earth Science Skillcards:
No. 30 - Earth's Crust - Topographic Maps for Section 17:7, page 334

Lab Manual: Earth Science - A Learning Strategy for the Laboratory
No. 50 - Stream Patterns, pages 119-121
No. 51 - Profile of a Coastline, pages 123-126

Earth Science Activity-Centered Program, Teacher's Guide
Page 134 - Preparation Notes
Page 135 - Extensions to Activity 17-1
Page 136 - Extensions to Activity 17-2
Page 137 - Extensions to Activity 17-3
Page 138 - Extensions to Activity 17-4
Page 140 - Additional Activity

Focus on Earth Science Review and Reinforcement Guide
17:1 - Contour Lines, page 83
17:2 - Interpreting Contour Lines, page 84
17:3 - Constructing a Contour Map, page 85
17:4 - Selecting a Building Site, page 86
17:5 - Landforms Crossword Puzzle

Additional Suggestions:
A, B, C, exercises, pages 347-349
Points to Remember, page 347
Words to Use, page 347
How and Why, page 349
More Ideas to Explain

PERFORMANCE OBJECTIVES	SUGGESTED ACTIVITIES
The student will -- Recognize that mountains can be classified as structural, volcanic, or dissected according to how they were formed.	Point out the landscape of Bryce Canyon, page 322, of the textbook. Begin a class discussion on landforms by asking students to describe the original landscape, what changed the landscape, and how it may look in the future. Define landforms and emphasize that each landform was created as a result of some process that occurred on or within the earth's crust. Display a relief map of North America and have students identify the following: a. Rocky Mountains b. Appalachian Mountains c. Colorado Plateau d. Great Plains e. Coastal Plains f. Central Lowlands Have students explain the correlation between mountain building and movement of the earth's plates. *Students could construct models of various mountain ranges. @ Have students do a library investigation on "Mountain Ranges." Have them use reference materials in the library to find the location, approximate length, and highest peak of these mountain ranges: Himalayas — Sierra Madre Alps — Cascades Rockies — Appalachians Urals — Pyrenees Students could do Skillcard No. 30 - "Topographic Maps." Have students do the activity on page 345 - "Contouring a Dissected Hill." Read about Patricutin, the volcano that suddenly erupted from a Mexican cornfield. *Make charts to show how different kinds of volcanoes are formed. Collect pictures on different kinds of volcanoes.

PERFORMANCE OBJECTIVES	SUGGESTED ACTIVITIES
The student will --	@ Students could report on the rising of a volcano such as Krakatoa, Pelee, Mauna Loan, Kilauea, Vesuvius, or Etna.
Identify igneous rock formations, plains, and plateaus, and give examples of each.	Have students make models of igneous rock bodies; use figures 17-10 on page 330. Some students may have visited Enchanted Rock in the Llano area of Texas and could bring pictures and describe the shape of this "hill." Students could research to find out the type of rock body. Students could use reference material in the library to find out regions in the United States where volcanic and plutonic igneous rock appear at the surface. Then draw a map of the United States and locate these regions. @ Have students look up information on the Idaho Batholith Palisades Rock Formation, Giant's Causeway, Stone Mountain, The Rock of Gibralter, and Garden of the Gods. Have students identify the plains area of the United States by naming the states that have plains and pointing them out on a map of the United States. Discuss the importance of the Great Plains to agriculture. Describe the Appalachian and Colorado Plateaus.
Use a topographical map to determine landforms and climates.	Students could report on drainage patterns of large rivers such as the Amazon, Congo, Yellow River, Mississippi river, and Ohio River. Have students do Lab No. 50 - Stream Patterns, page 119 of the Lab Manual. In this activity, students will draw a random stream pattern and compare it to actual stream patterns. Review the surface changes caused by running water, underground water, glaciers, and wind. Review the landscapes they form. *Have students collect as many pictures of different landscapes as possible. Post these pictures in the classroom to reinforce the student's understanding

PERFORMANCE OBJECTIVES	SUGGESTED ACTIVITIES
The student will --	of how different the land appears when acted upon by different agents. Discuss the Houston-Galveston area and the major erosional agents which have shaped the surface features. Point out the difference between the rocky coast of California and Oregon and the low-lying Gulf of Mexico coastline, by using pictures, filmstrips, slides, and/or topographic maps of these regions. This will help students understand how erosion alters topography. Have students review topographic map symbols and rules in Chapter 2. Have students do exercise 17:1 - Contour Lines; 17:2 - Interpreting Contour Lines; and 17:3 - Constructing a Contour Map, pages 83-85 in the Review Guide. Students should do Lab No. 51 - Profile of a Coastline. In this activity students will draw a profile from the shore of Galveston. @ Students could do exercise 17:4 - Selecting a Building Site, page 86 of the Review Guide. Students should answer questions 5-11 on page 338 of the textbook. Have students do activities 17-1 through 17-4, all of these are associated with interpretation of topographic maps. Have students compare Galveston or Padre Island with Oceanside, California. Use the Grand Canyon map to compare with Soda Canyon. Have students do the additional activity on page 140 of the Activity Book. *Have students do Focus on Skills, page 346 in the textbook.

PERFORMANCE OBJECTIVES	SUGGESTED ACTIVITIES
The student will --	

PREPARATION NOTES

BEFORE BEGINNING THE NEXT UNIT, YOU MIGHT WANT TO ORDER THE FILMS LISTED FOR CHAPTER 19. WRITE OR CALL THE COMPANY TO ORDER FILMS. SEE THE BUSINESS SECTION OF THE TELEPHONE BOOK FOR MORE INFORMATION.

UNIT VI

EARTH'S HISTORY

Chapter 18: Dating Geologic Time (Optional)

Major Concepts to be Taught

Earth's age has been measured from rates of change in earth materials.
Role of rocks, radioactivity, and fossils in estimating the age of the earth.

Instructional Objectives

The student should be able to:

- Explain how man has attempted to determine the age of the earth by use of:
  a. the sedimentation method as it relates to the law of superposition
  b. radioactive clocks
  c. fossils
- Give scientific reasons for the changes in life forms.

Assessment Guidelines

The student will:

- Explain the law of superposition
- Define unformities
- Describe geologic column
- Give the approximate age of the earth
- Explain the use of radioactive elements in geologic dating
- Explain the importance of rocks in geologic dating
- Explain the importance of fossils in geologic dating
- Define radioactive half life
- Distinguish between index fossils and facies fossils
- Define paleontology
- Give two kinds of influences that may cause changes in life patterns.

Materials

Textbook: Focus on Earth Science, pages 350-373

Lab Manual: Earth Science - A Learning Strategy for the Laboratory
No. 52 - Measuring Geologic Age
No. 53 - Carbon Impressions
No. 54 - Volcanic Preservation
No. 55 - Law of Superposition
No. 57 - Differences in a Species

Earth Science Activity-Centered Program - Teacher's Guide
- Page 142 - Can you Interpret the Geologic History of a Region?
- Page 147 - Can you Determine the Age in Years for Some Rocks?
- Page 149 - How do the Half-lives of Elements Differ?

Focus on Earth Science Review and Reinforcement Guide
- 18:1 - Fossils and Nonfossils, page 89
- 18:2 - The Order of Rock Deposits, page 90
- 18:3 - Past Geography and Life, page 92
- 18:4 - The Half-life of Carbon

Additional Suggestions:
- Points to Remember, page 371
- Focus on Skills, page 370
- Words to Use, page 371
- Questions for Review A,B,C, pages 371-373
- How and Why, page 373
- More Ideas to Explore, page 373

Films:
- 6356 Fossils - From Site to Museum, 11 Min., 16mm
- 5890 Dinosaurs - The Terrible Lizards, 11 Min., 16mm

PERFORMANCE OBJECTIVES	SUGGESTED ACTIVITIES
The student will -- Explain how man has attempted to determine the age of the earth by: a. Use of the sedimentation method as it relates to the law of superposition	Have students interpret the geologic history of a region. See the activity on page 142 of the Activity Book. Begin this activity with a discussion of the principle of superposition. @ Have the more advanced students extend the above activity of doing the extensions on page 144 of the Activity Book. Students should do Making Sure, No. 1, page 356 of the textbook. Make copies of figure 18-3 on page 367. Distribute these copies to students and have them complete the activity on page 356 of the textbook. Make copies of Figure 18-3 on page 357. Distribute these copies to students and have them complete the activity on page 356 of the textbook. Have students do Lab No. 55 - Law of Superposition, page 133 of Lab Manual. Students should do exercise 18:2 - The Order of Rock Deposits, page 90 of the Review Guide.
b. Use of radioactive clocks	@ Have students draw the uranium 238 decay series in their notebooks and add to it the number of neutrons for each daughter product. See page 147 in the Activity Book for more details. Then have students make a graph showing the number of neutrons emitted by each element. Students should calculate the age of rock based on radioactive decay data by doing Lab No. 52 - Measuring Geologic Age, page 127 of the Lab Manual. Students should determine how the half-lives of elements differ and then correlate data to construct a line graph showing how mass changes with time. See page 149 of the Activity Book for more details. Do exercise 18:4 - The Half-Life of Carbon - 14, page 94 of the Review Guide.

PERFORMANCE OBJECTIVES	SUGGESTED ACTIVITIES
The student will -- c. Use of Fossils	The student should define and explain the importance of index fossils. Film #6356 - Fossils from Site to Museum Library Assignment: Students can report on such places as Dinosaur National Monument, La Brea Tar Pits, Agdate Fossil Beds, Petrified Forest, etc. Students should emphasize such things as location of parts, types of fossils, guide fossils, etc. and geologic time scale or period. Film #5890 - Dinosaurs Do exercise 18:1 - Fossils and Nonfossils, page 89 of the Review Guide. Students should do Lab No. 53 - Carbon Impressions and Lab No. 54 - Volcanic Preservation on pages 129-132 of the Lab Manual. More Ideas to Explore, page 373 of the textbook. Students will apply their knowledge of facies fossils. Do the activity on page 368 of the textbook.
Give scientific reasons for the change in life forms.	Library assignment: Students could report on the studies of Charles Darwin and Alfred Wallace. Also investigate unique life forms due to isolation in places such as Australia and Africa, and make a report to the class. Do Lab No. 57 - Differences in Species, page 141 of the Lab Manual. Students could do 18:3 - Past Georgraphy and Life, page 92 of the Review Guide. *Library assignment - Prepare report on stratigraphers and paleontologists, with emphasis on career training and preparation, also job related duties. @ Organize a debate with students attempting to prove or disprove the earth's age.

Chapter 19: Earth Through Geologic Time (Optional)

Major Concepts to be Taught

Development of Geologic Time Units
Importance of the fossil records during the Paleozic and Mesozoic eras
Development of the Cenezoic era
Development of the geologic time scale

Instructional Objectives

The student should be able to:

- Comprehend the basis of geologic time scale and the time between events in early history.
- Describe the conditions and life that existed during each period of the era.
- Tell how the fossil record shows changes in the kinds of living things.

Assessment Guidelines

The student will:

- Name the eras into which geologic time is divided and state approximately how long ago each began.
- Define:

precambrian time	Mesozic era
eons	Cenozoic era
era	fossil
Paleozic era	period

- List the periods of the Paleozic era.
- Describe the events that occurred during the Mesozoic era.
- Discuss the two periods of the Cenozoic era.
- Name the kinds of life that existed during the main periods of the Paleozic, Mesozoic, and Cenozoic eras.
- Know about the kinds of dinosaurs and describe the conditions which caused them to become extinct.

Materials

Textbook: Focus on Earth Science - pages 374 -393

Lab Manual: Earth Science "A Learning Strategy for the Laboratory"
No. 56 - Geologic Time

Earth Science Activity-Centered Program, Teacher's Guide
Page 151 - Can you make a scale drawing to illustrate the length of geologic time?
Page 152 - Can you correlate life forms with different time units?
Page 154 - Extensions to Activity

Focus on Earth Science Review and Reinforcement Guide
19:1 - Life Names, page 95
19:2 - A Debate About Dinosaurs, page 96
19:3 - Life and a Time Map

Films:
A World is Born - Disney
Story in Rocks - Shell Oil Company - 17 min.
Galveston Island Barrier Sands - Exxon Company - 30 min.
Andros Reef Tract - Sun Oil Company - 55 min.

PERFORMANCE OBJECTIVES	SUGGESTED ACTIVITIES
The student will --	Students could make a drawing to illustrate the length of geologic time. See Page 151 of the Activity Book for details. @ Have students illustrate life forms on the scales, mountain building events, as well as major volcanic activities.
Comprehend the basis of the geologic time table and the time between events in early history.	Time tape of geologic time - Activity Sheet 1 is similar to the above activity. Use reference books such as Geology books to find names of the periods. Prepare a chart showing each era and its periods. Explain your chart to the other students. Place the best charts on the bulletin board. Name the four geologic eras. Explain how they are divided into periods. Which Era? - Activity Sheet 2
Describe the conditions and life that existed during the period of the different era.	Use library books to prepare a report on prehistoric animals and plants. Give reports orally. Have each student make a picture of his animal or plant. Take all of the pictures and make a mural for the wall or bulletin board. Place living things in the correct era. Have students correlate life forms with the different time units by completing the activity on page 152 of the Activity Book. Students could collect leaves from as many different environments as possible. Mount the leaves for display, identify each leaf and its environment on a label. See page 154 of the Activity Book for more details. @ Have students make charts or maps showing geological as well as plant and animal changes as a diary for the eras. Students should do Lab No. 56 - Geologic time, page 137 of the Lab Manual.

PERFORMANCE OBJECTIVES	SUGGESTED ACTIVITIES
The student will --	Students could do the following activities on pages 95-99 of the Review Guide: 19:1 - Life Names 19:2 - A Debate About Dinosaurs 19:3 - Life and a Time Map Library Investigation: Study about the research work done by Dr. Louis S.B. Leaky and his wife Mary Leaky. Make a report to the class.
Recognize how the fossil record shows changes in the kinds of living things.	Look up information about the dinosaurs (e.g., Brachiosaurus, Triceratops, Plesiosaurus, Anklyosaurus). In a written report include a description of each dinosaur and its habitat and tell why it did not survive. Demonstrate how fossils are formed by doing the activity on page 379 of the textbook. Have students complete the activities on page 386 and 389. Find out about museum careers by writing to the American Association of Museums, 1055 Thomas Jefferson Street, N.W., Washington, D.C., 20007. Visit the Museum of Natural Science to observe the actual fossil remains of prehistoric animals. On small index cards, record the name of the animal; the geologic era and period in which it lived, and its physical characteristics. @ Have more advanced students research the evidence that has led scientists to believe that another ice age is coming. Have a debate on the pros and cons of "Is Another Ice Age Coming?"

ACTIVITY SHEET NO. 1

Time Line Activity

Purpose:

To show events in the history of the earth by the use of a time line measured on adding machine tape.

Materials:

Tape from adding machine, 5 meters long, meter stick, pencil, colored pencils, reference books showing a geologic time scale.

Procedures:

1. Make a geologic time scale on your tape using a scale from your reference book.
   1 meter - 1 billion years
   1 decimeter - 100 million years
   1 centimeter - 10 million years
   1 millimeter - 1 million years

2. Mark lines across the tape to represent the beginning and end of geologic eras, periods, and epochs.

3. Write the names of the eras down the left-hand side of the tape. Write the periods across the tape under the lines that separate the periods.

4. Write in the major events that occurred in each period.

5. Make each period and era a different color.

Conclusion:

1. What length on your time line represents the time from the beginning of earth history to the time fossils became common?

2. Look up some kinds of fossils and describe them.

3. Make a drawing of three kinds of fossils.

4. Select two dinosaurs and tell something about their habitat

ACTIVITY SHEET NO. 2

WHICH ERA?

A. Name the era

1. That is the oldest _____
2. That is the youngest _____
3. That lasted the longest _____
4. In which we live _____
5. During which dinosaurs lived _____
6. That had the simplest life _____
7. During which flowering plants first grew _____
8. That had many shell animals _____
9. That had many layers of thick forests _____
10. During which the first land animals lived _____

B. In which era

11. Did insects first appear? _____
12. Did early reptiles develop? _____
13. Was there only sea life? _____
14. Did coal form? _____
15. Did mammals first appear? _____
16. Did dinosaurs die out? _____
17. Did birds first develop? _____
18. Would you find King Kong? _____
19. Was very warm and moist? _____
20. Would you like to live? _____

UNIT VII

EARTH: ENVIRONMENT

Chapter 20: Renewable Resources

(Suggested Time: 3 days - One Semester)
7 days - Two Semesters)

Major Concepts to be Taught

Renewable resources and how we use them
Impact of air and water pollution on the environment and people
Ways to cope with problems presented by misuse of natural resources

Essential Learner Outcomes

The student will -

- Name three substances obtained in commercial quantities from the earth that are found within 100 miles of Houston.
- List at least two conditions that exist on planet earth that enables life as we know it to exist.

Instructional Objectives

The student should be able to:

e . Define environment and explain how both nature and people change the environment.
e . Identify renewable resources and explain why clean air is important.
e . Explain three different uses of land resources.
e . List the earth's available water resources, usesd of water, and discuss sources of water pollution.

Assessment Guidelines

The student will:

- Describe some natural effects on the environment.
- Describe some human effects on the environment.
- Explain how increase in population affects the earth's resources.
- Describe the difference between a renewable resource and a non-renewable resource.
- Define a natural resource.
- Describe some problems people face when using the land.
- State how much water is used by people in the United States each day.
- List three causes of water pollution.
- Name some of the existing water supplies.
- Explain how man is coping with the problem of water pollution.
- List three causes of air pollution.
- Describe what is being done to help stop air pollution.

Materials

Textbook: Focus on Earth Science, pages 394-415

Earth Science Skillcards:
- No. 55 - Running Water, Part I
- No. 56 - Running Water, Part II
- No. 57 - Contour Plowing

Lab Manual - Earth Science: "A Learning Strategy for the Laboratory"
- No. 58 - Smoke Pollution
- No. 59 - Sediments
- No. 60 - Soil Infiltration by Groundwater
- No. 61 - Water Purification
- No. 62 - Human Impact on the Environment

Focus on Earth Science Activity-Centered Program, Teacher's Guide
- Page 159, What will happen as human population expands?
- Page 161, Extensions to Activity 20-1
- Page 161, How will the development of swampland affect the local environment?
- Page 164, Extensions to Activity 20-2
- Page 164, How does thermal pollution affect Daphnia?
- Page 167, How can students investigate the community resources?

Focus on Earth Science Review and Reinforcement Guide
- 20:1 - Effects on the Environment, page 101
- 20:2 - Vocabulary of Renewable Resources, page 102
- 20:3 - Acid Rain, page 104

Additional Activities:
- Questions in Exercises A, B, and C, pages 413-415
- Points to Remember, page 413
- Words to Use, page 413
- How and Why, page 415
- More Ideas to Explore, page 415
- Focus on Frontiers, page 412
- Start a School Clean-Up Campaign
- Guest speakers from companies explaining how pollution is being controlled.

Films:
- M5673 - Aging of Lakes, 14 min.
- 7028 - Air, 3 min.
- 4620 - Air Pollution, 10 min.
- M3852 - Water Harvesting, 16 min.
- M7492 - Pollution of Upper and Lower Atmosphere, 17 min.

PERFORMANCE OBJECTIVES	SUGGESTED ACTIVITIES
The student will – Define environment and explain how both nature and people change the environment.	*Have students list as many things as possible that they notice about their environment. Begin a class discussion on the environment and its definition by having students compare their observations about their environment. Students should do "Making Sure," page 398, questions 1-4. Have students decide which effects on the environment are due to natural causes, and which are due to actions of people. See exercise 20:1 - Effects on the Environment, page 101 in the Review Guide. Find out what will happen as human population expands by doing the activity on page 159 in the Activity Book. Have students check populations and land area for the United States, China, U.S.S.R., Great Britain, Mexico and Brazil. Place this information on charts or graphs.
Identify renewable resources and explain why clean air is important.	Define renewable resources and list five of them. Discuss what might happen if man continues to pollute and carelessly use the renewable resources available today. Have students do exercise 20:2 - Vocabulary of Renewable Resources, page 102 in the Review Guide. Discuss ways that air becomes polluted. Determine if the air in your area contains large amounts of dust or particles. Do the activity on page 400 of the textbook. Have students do Lab No. 58 - Smoke Pollution on page 143 of Lab Manual. *Take the class on a walk around the neighborhood. Have students make a list of any evidences of people, places, or things causing air pollution. Have a classroom discussion about student's observations.

PERFORMANCE OBJECTIVES	SUGGESTED ACTIVITIES
The student will --	Have students find out what the Environmental Protection Agency has done to help clean up the air, by using reference materials found in the library. Visit or write letters to a number of industries. Have students prepare a brief questionnaire to send with their letters. @ Have students read "Acid Rain," exercise 20:3, page 104 in the Review Guide.
Explain three different uses of land resources.	*Students could make collages showing different uses of land. Give students copies of a world map and have them show where food is produced using different colors. Compare this map to the population map. Students could determine how the development of swampland affects the local environment. See page 161 in the Activity Book for details. Do the activity on page 411 of the textbook. In this activity students find out if litter is harmful to the environment. Have students identify sources of land pollution within their community and suggest possible solutions to these land pollution problems. Start a cleanup campaign of the school grounds.
List the earth's available water resources, uses of water and discuss sources of water pollution.	*List some of the home uses for water. Have students look at the circle graph on page 407 of the textbook, and determine where the greatest amount of water is located. Answer question 8 and 9, page 408 - Making Sure. Students should do the activity on page 408 of the textbook. Have students do the following experiments found in the Lab Manual: Lab No. 59 - Sediments, page 147 Lab No. 60 - Soil Infiltration by Groundwater Lab No. 61 - Water Purification

PERFORMANCE OBJECTIVES	SUGGESTED ACTIVITIES
The student will --	Students could determine how thermal pollution affects Daphnia by doing the activity on page 164 of the Activity Book. @ Have students write to the Environmental Protection Agency to find out what the EPA is doing to control water pollution. Students could do Lab No. 62 - Human Impact on the Environment, page 155 of the Lab Manual. In this activity students will observe people's impact on the environment and suggest ways people can change their impact on the environment. Students could investigate the community resources. See page 167 of the Activity Book for details.

Chapter 21: Nonrenewable Resources

(Suggested Time: 3 days - One Semester)
7 days - Two Semesters)

Major Concepts to be Taught

The limitations of our nonrenewable resources
Valuable products of the earth's crust (ores) include metals and nonmetals
Where ores are likely found and problems caused by mining
Ways these resources can be conserved

Essential Learner Outcomes

The student will -

- Name three substances obtained in commercial quantities from the earth that are found within 100 miles of Houston.
- List at least two conditions that exist on planet earth that enables life as we know it to exist.

Instructional Objectives

The student snould be able to:

B . Explain what an ore deposit is.
e . List important metals and nonmetals and compare their characteristics.
. Name and describe some precious and semiprecious gems.
. Describe some types of ore deposits and problems caused by mining.
e . Discuss ways that our nonrenewable resources can be conserved.

Assessment Guidelines

- Define an ore.
- List characteristics of metals.
- Explain the different ways metallic ores have been deposited.
- Name five useful metals.
- Name five useful nonmetallic ores.
- Describe how a precious stone differs from a semi-precious stone.
- List four types of ore deposits.
- Discuss current problems of mining.
- Discuss the benefits of recycling.

Materials

Textbook: Focus on Earth Science, pages 416-437

Lab Manual: "Earth Science - A Learning Strategy for the Laboratory"
- No. 63 - Mineral Resources
- No. 64 - Removal of Waste Rock
- No. 65 - Reclamation of Mine Wastes
- No. 66 - Conservation - Recycling

Focus on Earth Science Activity-Centered Program, Teacher's Guide
- Page 169, Can you predict the effect on the mining of gold...?
- Page 172, Extensions to Additional Activity
- Page 174, Extensions to Activity 21-2
- Page 175, Extensions to Activity 21-3
- Page 176, Which objects found in your immediate environment are metals? Which are nonmetals?
- Page 177, Extensions to the additional activity

Focus on Earth Science Review and Reinforcement Guide
- 21:1 - Ores, page 107
- 21:2 - Kinds of Resources, page 108

Additional Suggestions:
- Exercises A, B, C, pages 435-437
- Points to Remember, page 435
- Words to Use, page 435
- How and why, page 437
- More Ideas to Explore, page 437

PERFORMANCE OBJECTIVES	SUGGESTED ACTIVITIES
The student will -- Explain what an ore deposit is.	Have your students demonstrate how metals can be obtained from ores. To do this, put a small amount of black copper oxide and powdered charcoal into a test tube. Gently heat the test tube for several minutes, then pour the mixture into a beaker of water. The copper will settle to the bottom of the beaker and the charcoal will remain floating on top of the water. Have students do Lab No. 21 - Removal of Waste Rock. This activity demonstrates how industry separates wanted from unwanted material. Have students do Exercise 21:1, Ores. The students will assume they are geologists evaluating an ore body for possible mining. See page 107 in Review Guide. Hand out copies of "Flow of Iron to, from, and in North America." In this activity students will determine where iron ore is mined. Have students do "Production of Iron Ore and Steel." Hand out copies of this activity. In this activity, students will plot a graph showing where iron ore is mined and steel produced.
List important metals and nonmetals and compare their characteristics.	Have students predict the effect on the mining of gold by plotting the world price over a period of time. This activity is on pages 169-172 of the Activity Book. Have students do Lab No. 63 - Mineral Resources. In this activity students will list the metal and nonmetal resources they use daily. @ Have students do the extensions activity on page 172 of the Activity Book. Have students draw or trace a map of the world. Students should locate and label Africa, Asia, Europe, North America, South America, Australia, and Antarctica. Then they find out where uranium, sulfur, aluminum, iron, halite and gold deposits are located and label the places on their maps.

PERFORMANCE OBJECTIVES	SUGGESTED ACTIVITIES
The student will --	Have students do "Best Location for Mineral Grains." This activity demonstrates where would be the best location in a stream to look for mineral grains. Give each student a copy of this activity. Students could do "Recovering Placer Deposits." Give each student a copy of this activity. Have students report on the diamonds of South Africa and Brazil and the recovery of the diamonds. Students could also report on the tin deposits of the South Pacific and how they occur. Have students do exercise 21:2 - Kinds of Resources, page 108 of the Review Guide.
Name and describe some precious and semiprecious gems.	Have students give an oral report on preparing and marketing any gem. Students could write a report on diamonds. They should include in their report why diamonds are valuable, some uses of diamonds and how synthetic diamonds are made. If you did not invite a jeweler to speak with your class earlier, you may want to ask one to visit your class to help students appreciate the work of gem cutters.
Describe some types of ore deposits and problems caused by mining.	Read pages 428-432 and discuss the current problems of mining such as shaft mining, strip mining, presence of acid water. Do Making Sure - No. 4, page 432. Students should determine how coal mining pollutes underground water, lakes, and streams. Have them do the activity on page 432 of the textbook. @ Have students do Extensions to Activity 21-3, page 175 of the Activity Book. Students could do Lab 65 - Reclamation of Mine Wastes, page 163 of the Lab Manual. Do More Ideas to Explore - Nos. 1-3, page 437 of the textbook.

PERFORMANCE OBJECTIVES	SUGGESTED ACTIVITIES
The student will -- Discuss ways that our non-renewable resources can be conserved.	Discuss recycling now and possibilities for the future. Start a recycling project in your school. You may want to involve other classes and parents. Check with the school custodial staff and the administration and include them in recycling school waste materials. Read Focus on Frontiers on page 434. Have students do Lab 66 - Conservation--Recycling, page 165 of the Lab Manual. In this activity students will collect waste materials, find out what companies reuse such materials, and interview a representative of a company and learn how they recycle. Do the activity on page 175 of the Activity Book.

The following activity alerts students to the importance of iron in the United States economy and, at the same time, indicates the importance of transportation in the processing of industrial and metallic minerals. When minerals are far from processing centers, they often cannot be mined economically.

Title:

Flow of iron to, from, and in North America

Problem:

What determines where iron ore is mined and iron and steel produced in North America.

Time Sequence:

Initial	*Daily*	*Final*	
30	none	none	minutes

Materials:

colored pencils, four different colors
map of North America indicating centers of iron and steel production, areas where iron ore is mined, and regions with unmined deposits of iron ore (Figure 1)
map of the world

Procedure:

1. With a colored pencil, shade in the areas on the map of North America where most iron ore is mined.
2. With a second colored pencil, shade in the areas where undeveloped prospects have been found.
3. With a third colored pencil, shade in the areas where most of the iron and steel industry is concentrated.
4. With the fourth colored pencil, draw lines to indicate the logical routes for iron ore to travel from where it is mined to an iron and steel processing center.
5. Japan produces very little iron ore, but more steel than any European country except Russia. Australia, South America, the western United States, and East Africa ship much of their ore to Japan for processing. On the world map, estimate the distances by water routes between Los Angeles and each of the following: Japan, Chicago, Baltimore (nearest port to Pittsburgh), Houston, and Mobile. Write those distances on the map of North America.

Observations:

Processing centers generally are near industrial centers and near sources of coke and limestone. Iron ore moves toward the nearest processing center

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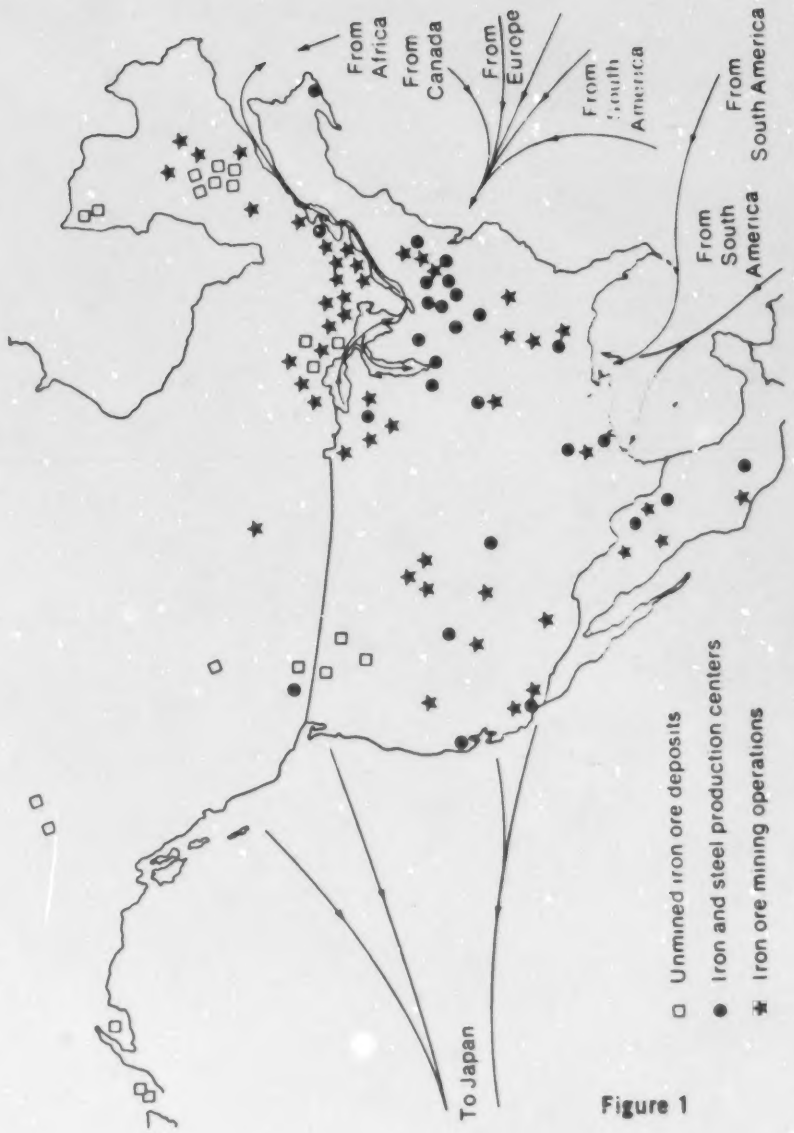

Figure 1

by water routes, if possible. Long transportation overland is more expensive than by ship. By water routes, Los Angeles is nearly 5,000 mi from the east coast of the U.S., 7,457 mi from Chicago, 4,857 mi from Baltimore, 4,000 mi from Houston and 4,326 mi from Mobile. Los Angeles and Japan are only about 5,507 mi apart. Undeveloped prospects in North America are principally in Canada, Alaska, Idaho, Washington, and Minnesota. All of these prospects are far from industrial centers, and many are far from water transportation.

Conclusions:

The steel industry is concentrated in the eastern industrial region of the United States, partly because of the location of the coal resources, partly because of cheap transportation from the great concentrations of iron ore near the Great Lakes. West Coast iron ore is shipped to Japan because it is cheaper to send it there than to the Eastern Seaboard. Other countries with ports near their iron resources also send their ore to Japan because it is more economical to do so than to send it to the U. S. or Europe, or to invest in processing facilities.

Questions:

1. **Where in North America is the greatest concentration of iron ore bodies?** Near the Great Lakes in Minnesota and the Northern Peninsula of Michigan
2. **Where does most of this ore go to be processed?** Chicago, Pittsburgh, and various cities in Ohio
3. **Where does most of the ore from Missouri go for processing?** Texas, Chicago, and St. Louis
4. **From the water route distances which you determined between Los Angeles and various other cities, suggest a reason why the western iron ore is sent to Japan for processing.** It can be shipped by freighter more cheaply than by any other means of transportation. When the distance is measured around the Panama Canal, it is as close to Japan as to Pittsburgh.

The following activity can be used to give students some experience in statistics and to help them compare the industrial activities of the continents.

Title:

83 Production of Iron Ore and Steel

Problem:

How does the production of iron ore compare with the production of steel for the various continents? How has the amount of iron ore and steel production on each continent changed?

Time Sequence:

Initial	*Daily*	*Final*	
30	none	none	minutes

Materials:

graph paper, 2 sheets
colored pencils, two different colors (optional)
ruler

IRON ORE AND STEEL DATA

Region	IRON ORE MINED (Thousands of Gross Tons)			STEEL PRODUCED (Thousands of Net Tons)		
	1945	1955	1965	1945	1955	1965
Canada	1,998	14,539	35,527	2,803	4,500	10,024
Mexico	278	705	2,503	211	580	2,685
United States	88,377	102,999	87,842	79,702	117,036	131,462
North America	90,653	118,243	125,872	82,716	122,116	144,171
U.S.S.R.	17,716	70,727	150,584	13,800	50,265	100,303
Europe	52,984	194,146	298,310	36,547	152,387	272,744
Japan	1,334	1,492	2,467	2,302	10,370	45,383
Asia	8,669	19,906	80,981	3,906	15,425	67,829
Africa	3,656	11,879	38,730	588	1,553	3,753
South America	1,677	15,268	53,562	360	1,525	6,202
Oceania	1,570	3,573	6,921	1,508	2,458	5,786
Others	8	402	661	1,416	2,012	912
World Totals	159,441	363,417	605,637	127,041	297,476	501,407

Procedure:

1. Set up one sheet of graph paper as shown in Figure 1. Put a vertical scale from 0 to 300 million tons on the left hand side of the paper. Divide the sheet into 5 sections, then divide each of these into two units, one for each 10 year interval.
2. Plot the iron ore mined and steel produced for each of the five continents. Use one section for each continent. Use a different colored pencil, or dot one line so that you can distinguish between the lines representing iron ore and the ones representing steel. When plotting, round off figures to the nearest million tons.
3. In your graph for Asia, you may wish to add Japan as in Figure 1.
4. In your plot for Europe, you may wish to add the U.S.S.R. as in Figure 1.
5. On the second sheet of graph paper use a scale from 100,000 to 600,000 and plot the world production of iron ore, and the world production of steel over the same 20-year period.

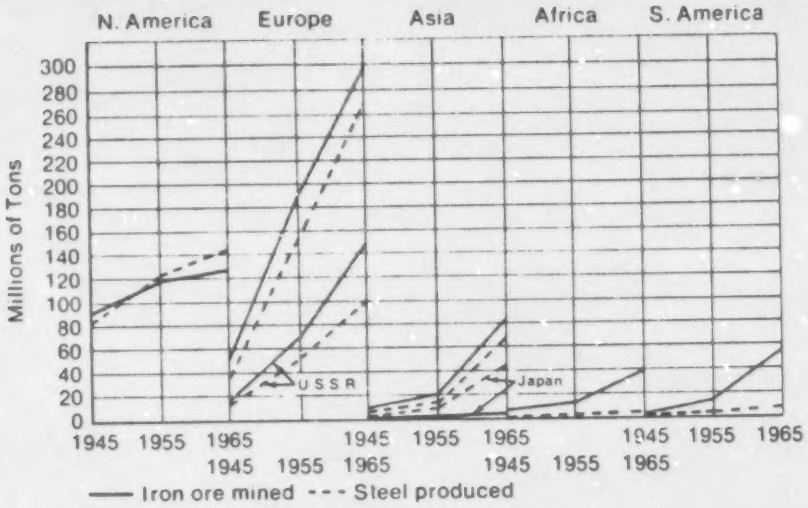

Figure 1

Observations:

Except for North America, Africa, and South America iron ore production and steel production lines are approximately parallel. North America produces more steel than iron ore. Africa and South America produce more iron ore than steel. Japan produces almost no iron ore but produces most of the steel for Asia.

Conclusions:

North America is becoming deficient in the iron ore needed to keep its steel mills producing, and ore must be imported. Africa and South America are producers of ore, but their industrial complex is not yet producing much steel. Europe produces both the most iron ore and the most steel.

Questions:

1. **Where does the iron ore come from to supply the steel mills of North America?** Much of it must come from Africa and South America.
2. **Where does the iron ore come from to supply Japan's steel mills?** From the graph, it appears that most of it comes from Asia, but some comes from western U.S.
3. **What do the graphs indicate about the industrialization of the world in general?** It is becoming more and more industrialized as shown by the constant increase in steel production.
4. **Which countries of the world are most industrialized?** North American and European countries **How do you know?** From the graph, these are the largest steel producers.

5. **Since 1955, which country appears to have made the most progress toward industrialization?** Japan
6. **From the graph, which countries appear to be the least industrialized?** Africa and South America
7. **Do you think that iron ore is becoming more or less important in world industry?** more important
8. **In what areas can we look for new iron ore resources?** South America, Africa, and Asia

The following activity, which may be used for Chapter 8 or Chapter 19, shows methods that industry uses to obtain the maximum possible recovery from petroleum reservoirs. These techniques are called secondary recovery methods, and they depend on furnishing energy to the oil reservoir to force the oil to the surface.

Title:

Secondary Recovery of Oil

Problem:

How can the maximum amount of oil be forced to the surface from an underground reservoir?

Time Sequence:

Initial	*Daily*	*Final*	
45	none	none	minutes

Materials:

plasticine modeling clay, 1 lb
gravel, 2 cups
mineral oil, 1 cup
loaf cake pan, glass or clear plastic
drinking straws, plastic, three
water, 1 cup

Procedure:

1. Line the bottom of the pan with half the plasticine. Be sure that the plasticine is smoothed against the sides of the pan so that no water can leak to the bottom. Make the plasticine slope, or fashion an anticline (hill) with it.
2. When you are sure the plasticine is water tight, add the 2 cups of gravel to the pan. Make sure that the gravel slopes also, or push it into a hill that follows the slopes of the plasticine.
3. Place the three straws in the gravel. Straw 1 should reach the top of the gravel hill. Straw 2 should be about a half inch deeper in the gravel

3 should be pushed into the gravel until it almost reaches the plasticine layer. It should be about 1 inch lower in the gravel than Straw 2.

4. Now smooth the rest of the plasticine over the top of the gravel. Fashion it around the straws so they are completely sealed into the layers. Be sure that the plasticine is tight against the sides of the pan so no water can escape upward around the plasticine. (Figure 1.)

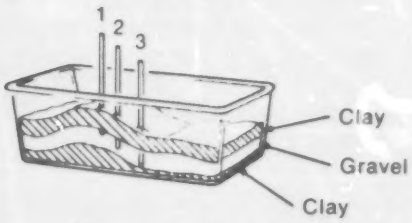

Figure 1

5. Pour water into Straw 3 until the water level is just above the bottom of that straw.
6. Pour oil into Straw 2 until the oil level is just below the bottom of Straw 1.
7. Hold your finger over the top of Straw 3 and blow into Straw 1. Record what happens.
8. Hold your finger over the top of Straw 1 and pour more water into Straw 3. Record what happens.

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Observations:

If your model is completely sealed, the air will force oil up the middle straw when you blow into the highest straw. When water is poured into the lowest straw, oil is forced through the middle straw if the top straw is sealed.

Conclusions:

Air forced into a reservoir from above the oil will force oil out of the well. Water forced into a reservoir from below the oil will also force oil out of the hole, provided no other opening is available.

Questions:

1. **Why do oil companies pump natural gas back into the ground in an oil field?** to force more oil out of the ground

2. **What is the purpose of water flooding in an oil field?** Water is pumped into the reservoir below the oil, and as the water fills more and more openings in the rock, the oil moves up the well opening.
3. **Secondary recovery methods are very costly. Why do you think they are used when much of the oil probably could be recovered without them?** Without secondary recovery some oil never would be recovered, a waste when oil is so much in demand.
4. **Gas can move through a reservoir faster than oil. Suggest a reason why.** Because oil is a fluid, there is more friction between it and the enclosing rock than there is with a gas. Gas also can use much smaller openings than oil can.
5. **Why would this activity not be successful if the plasticine did not form a perfect seal beneath the gravel?** The water would leak away beneath the plasticine, and it would not furnish any pressure on the oil.
6. **Why must you put your finger over Straw 3 in order to have the oil rise in Straw 2 when you blow into Straw 1?** If Straw 3 were not sealed, Straw 1 could have pushed the oil down into the water and water would have been pushed up into Straw 3.
7. **In the early days of oil production before the principles of oil movement were understood, natural gas sometimes was allowed to escape from wells into the atmosphere. Why is this practice now prohibited?** This is a waste of energy. Better use can be made of the gas by returning it to the reservoir to help bring oil to the surface.

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4. **Suggest a reason why the ocean currents do not follow this predicted route.** The Coriolis force and wind direction affect the ocean waters.

Using a map of the ocean currents, discuss some of the following questions with the students.

Suggested Questions:

1. **Is the Coriolis force more effective in the atmosphere or in the ocean?** Since water is in closer contact with the earth than the air, probably the turning of the earth affects the water more than the air.
2. **How do winds affect the ocean currents?** The wind pushes the surface currents in the direction of the wind.
3. **Why then do ocean currents in the trade wind zones flow toward the west?** Currents flow westward because the Coriolis force overcomes the effect of wind direction.
4. **Why do ocean currents turn north and south when they reach the American continents?** When the water comes into contact with the land, it cannot continue moving westward and must therefore move either north or south.
5. **The Equatorial Countercurrent seems to be running in the wrong direction. Suggest a reason for the position and direction of this current.** Some of the water carried westward in the tropics returns eastward in the zone of the doldrums where air currents are rising.
6. **Once currents begin moving poleward, why do they not continue in this direction?** Eventually they come under the influence of the winds in the zone of the westerlies. The ocean currents then move eastward before these winds until they encounter land. In the Pacific, the currents reach North America in the northern hemisphere. In the southern hemisphere, some water continues moving eastward, some is turned northward by the tip of South America. Europe and Africa deflect currents in the Atlantic.
7. **How do the Gulf Stream and Japanese Current affect the climates of North America and Asia?** These currents keep the temperatures warmer than they would be otherwise.
8. **What is the effect of the North Pacific Current on the west coast of the United States?** This is a cool current which keeps the west coast cooler than it would be otherwise.
9. **How is water returned to the equator?** Deep, cold currents from the poles replace the poleward moving surface currents.
10. **Suggest at least three ways in which the density of ocean water is constantly changed.** Evaporation makes the surface water more dense. Additions of fresh water, either by rain, melting ice, or rivers dilute the water. Freezing of ocean water releases salt to waters beneath the ice where addition of dissolved minerals increases density. Debris carried by turbidity currents also increases density.

The following activity may be used to illustrate the effect of density differences in ocean water.

Title:

Density Differences

Problem:

What causes different layers in ocean water?

Time Sequence:

Initial	*Daily*	*Final*	
20	none	none	minutes

Materials:

egg
pan
jar (1-qt capacity)
stirrer (rod or spoon)
salt, 1 cup
funnel (optional)
water, 3 cups

Procedure:

1. Warm 2 cups water in the pan and dissolve as much salt as possible in it.
2. Pour the brine which you have made into the jar.
3. Carefully pour the remaining water on top of the brine. You may use a funnel, or pour the water down the stirrer so that it does not mix with the brine.
4. Place the egg in the jar. Be careful not to disturb the fresh water layer.
5. Observe and record the position of the egg.
6. Remove the egg and the fresh water from the brine.
7. Place the brine in the freezing compartment of a refrigerator and leave it overnight. Observe what happens to the dissolved salt.
8. Taste the ice.

Observations:

The egg will float on the brine but sink through the fresh water. When the brine freezes, the salt comes out of solution. The ice that forms is fresh water.

Conclusions:

Layering in ocean water may result from fresh water floating on brine. Freezing removes salt from the surface layer and concentrates it in the water beneath.

BEST LOCATIONS FOR MINERAL GRAINS

Problem: Where would be the best location in a stream to look for mineral grains?

Materials:

- long shallow pan with hole in one end
- wood block
- water
- sand
- iron filings
- plastic bucket

Procedure:

1. Fill the pan half full of damp sand. Make a streambed with two definite curves. Form a hollow at the stream's mouth.
2. Elevate the end of the pan opposite the hole with the wood block. Pour some iron filings near the top of the stream.
3. Pour water into the streambed above the filings. Gently move the filings down the stream. Keep pouring water until some of the filings reach the mouth.
4. Sketch the stream and indicate where the filings collect. Record the number of filings for each curve and the mouth.

Results and Conclusion:

1. Do the iron filings seem to collect along one side of the curves? Which side?
2. Do they collect at any other place in the stream? Where and why?
3. Do many reach the mouth?
4. Where might a gold placer miner locate a gold deposit?
5. How do iron filings represent gold in placers? Why didn't you use gold?

RECOVERING PLACER DEPOSITS

Problem: How can you recover a placer deposit?

Materials:

Pie pan	ten BB's
sand	water

Procedure:

1. Fill a pie pan half-full with sand. Put ten BB's in the sand.
2. Fill the pan with water almost to the top. Shake the pan from side to side and with a rotary motion.
3. Pour off some of the sand and water, and be careful that the BB's do not escape.
4. Put more water into the pan and continue the process. Keep pouring sand and water away until only a small amount of sand is left. The BB's should still be in the pan.

Results and Conclusion:

1. Why do the BB's stay behind when the sand and water are poured away?
2. Gold is heavier than lead. Would gold be easier to pan than BB's?
3. Would this be a profitable way to recover gold?

Chapter 22: Energy Resources

(Suggested Time: 3 days - One Semester)
7 days - Two Semesters)

Major Concepts to be Taught

The forms of energy used today
The formation of fossil fuels
Alternative energy sources

Essential Learner Outcomes

The student will -

- Name three substances obtained in commercial quantities from the earth that are found within 100 miles of Houston.
- List at least two conditions that exist on planet earth that enables life as we know it to exist.

Instructional Objectives

The student should be able to:

e . Discuss the pros and cons of using water, windmills, solar energy, and nuclear energy as alternative energy sources.
e . Explain the formation of fossil fuels.
. Discuss the pros and cons of coal gasification, alcohol, tidal and geothermal energy as alternative energy sources.

Assessment Guidelines

The student will:

- Define energy.
- List four alternative energy sources and give one advantage and one disadvantage of each.
- Define fission and fusion.
- Define fossil fuels.
- Name three fossil fuels.
- Describe the steps in coal formation.
- Explain how petroleum and natural gas are formed and stored beneath the earth's surface.
- List possible future sources of oil and natural gas.

Materials

Textbook: Focus on Earth Science, pages 438-457

Lab Manual: Focus on Earth Science, A Learning Strategy for the Laboratory
- No. 67 - Wind Power, page 167
- No. 68 - Solar Energy Collector, page 171
- No. 69 - Solar Energy Storage, page 175
- No. 70 - Solar Energy Application, page 177

Focus on Earth Science Activity-Centered Program, Teacher's Guide
- Page 179, How can the maximum amount of oil be forced to the surface...?
- Page 181, Relationship between the number of barrels produced and the number of wells being drilled?
- Page 183, Extensions to the activity

Focus on Earth Science Review and Reinforcement Guide
- 22:1 - Using Energy
- 22:2 - Oil and Energy

Additional Suggestions:
- Exercise A, B, C, pages 455-457
- Points to Remember, page 455
- Words to Use, page 455
- How and Why, page 457
- More Ideas to Explore, page 457
- Focus on People, page 454

PERFORMANCE OBJECTIVES	SUGGESTED ACTIVITIES
The student will -- Discuss the pros and cons of using water, windmills, solar energy, and nuclear energy as alternative energy sources.	Have students answer question No. 1 - Making Sure, page 439. Have students name a type of energy produced by water power. Conduct a class discussion on the problems as well as the benefits of using water power. Students could check on the use of modern windmills and sailboats. Have students construct a device to measure wind speed and evaluate wind as a source of energy by doing Lab No. 67 - Wind Power, page 167 in the Lab Manual. Students could make working models of windmills. Discuss the advantages as well as disadvantages of using solar energy as an alternative source of energy. Have students experiment to find out how the color of materials affect its ability to absorb energy and graph the results. See the activity on page 441. Students could do the following experiments: a. Build a simple solar energy collector - Lab No. 68 - Solar Energy b. Construct storage tanks for heat energy, compare the ability of rocks and air to absorb and release energy - Lab No. 69 - Solar Energy Storage c. Design and construct a solar water heating system for your home - Lab No. 70 - Solar Energy Application Emphasize the differences between nuclear fission and nuclear fusion, and the problems of safety.

PERFORMANCE OBJECTIVES	SUGGESTED ACTIVITIES
The student will --	Students could report on the Three Mile Island accident on March 28, 1979, and any changes in safety practices which resulted. Do exercise 22:1 - Using Energy, page 109 in the Review Guide.
Explain the formation of fossil fuels.	Emphasize that fossil fuels are considered nonrenewable resources. Have students find out the products made from coal. Find out the location of the major coal deposits of the world. Have students write a paragraph describing the stages in coal formation. @ Students could do exercise 22:2 - Oil and Energy. Students could experiment to find out what happens to organic materials under conditions of decay, by doing the activity on page 178 of the Activity Book. Have students use library references to research the following: a. locating and drilling oil wells b. producing, transporting, marketing, and storing natural gas c. using petroleum in manufacturing plastics or rubber Students could do the experiment "Secondary Recovery of Oil." Have students do the activity on page 179 of the Activity Book. Students could do the activity on page 181 of the Activity Book. In this activity students will show a relationship between the number of barrels produced and the number of wells being drilled.

PERFORMANCE OBJECTIVES	SUGGESTED ACTIVITIES
The student will -- Discuss the pros and cons of coal gasification, alcohol, tidal and geothermal energy as alternative energy sources.	@ Report on the economic and political aspects of rising oil prices. This could be an interdisciplinary lesson with social studies courses. Discuss why coal is a possible source for gasoline and the problems created for the environment during coal gasification. Report on the various claims for and against the use of gasohol. Report on Greenland's present use of geothermal power. Use an outline map of the United States to indicate the areas where geothermal power may be possible. More Ideas to Explore No. 2, page 457 of the textbook.

Name Period Date

FOUR MEMBERS OF THE COAL SERIES

Purpose: To study the four members of the coal series: peat, lignite, bituminous coal, and anthracite.

Materials: Samples of - peat
lignite
bituminous coal
anthracite
crucible tongs
Bunsen burner

Procedure:

- Carefully examine the four specimens and describe the appearance of each as to (a) evidence of plant origin, (b) evidence of increased carbonization, (c) hardness, (d) luster, cleavage.
- Determine which is the youngest of the coal series and describe the evidence which indicates this.
- Determine what evidence indicates that anthracite is the most highly developed member of the coal series.
- Use your crucible tongs to hold a small bit of peat in a flame. Note how long it takes to ignite. Try to do the same with lignite, bituminous coal and anthracite coal. Note the following in each case: how easily it ignites, how smoky the flame, how rapidly it burns, and what kind of odor is produced. Record your observations.

MATERIAL	IGNITION	FLAME	SPEED	ODOR
Peat				
Lignite				
Bituminous Coal				
Anthracite Coal				

How does its manner of burning show that peat is the youngest member of the coal series?

How does the manner of burning show that bituminous coal still has gases in it?

UNIT VIII: THE UNIVERSE

Chapter 23: The Universe, Galaxies, and Stars

(Time Allotment: 3 days - One Semester)
5 days - Two Semesters)

Major Concepts to be Taught

The relationship between movements of body in space and gravitation
Knowledge about space depends upon a study of radiant energy.
The changes a star undergoes during its life cycle
The different types of galaxies and stages of stellar evolution
Tools used by astronomers to study the Universe

Essential Learner Outcomes

The student will -

. Using a ball, demonstrate and/or explain the action of gravity and describe what would happen if there were no force of gracity on the earth.
. Compare a planet with a star.

Instructional Objectives

The student should be able to:

e . Identify astronomers Ptolemy, Copernicus, Galileo, Kepler and Brache and associate them with their contributions to astronomy.
. Identify and explain the function of the optical telescope, radio telescope, spectroscope, and Schmidt telescope.
. Recognize types of knowledge gained about the Universe through the study of radiant energy.
. Explain what galaxies are and how they are classified.
. Distinguish between stars and other celestial objects.
. Explain how the H-R diagram is used in star classification.
. Point out and name some major constellations, and explain how they are named.
. Identify and explain some of the latest discoveries and inventions in astronomy.

Assessment Guidelines

The student will:

. Name five types of radiant energy.
. *Use a prism to show the colors of the spectrum.
. Define a light year.
. Tell how far light will travel in one year.
e . Explain what a star is.

. Define any two of these terms: magnitude, absolute magnitude, apparent magnitude, main sequence.
. *Identify the four colors of stars.
. *Give the color and temperature of our sun.
e . *Explain why the sun appears to us as the hottest and largest star if it is only an average star.
. Define any three of these terms: supergiants, white dwarfs, variable stars, novae, supernovae, cepheids
. Name and give the location of the largest observatory in Texas.
. Explain the function and shape of a radio telescope.
. Name new discoveries in astronomy.

Materials

Textbook: Focus on Earth Science, pages 458-479

Earth Science Skillcards:
No. 5 - Space and Space Travel - Light from Stars for Section 24:2, page 498
No. 6 - Space and Space Travel - Composition of Stars for Section 24:1, page 497
No. 7 - Space and Space Travel - Parallax for Section 24:2, page 498

Lab Manual: "Earth Science - A Learning Strategy for the Laboratory"
No. 71 - Refraction of Light
No. 72 - Star Trails
No. 73 - Sky Positions
No. 74 - Star Colors

Earth Science Activity-Centered Program, Teacher's Guide
Page 187 - Can you construct a spectroscope?
Page 189 - Extensions to the activity
Page 189 - Can you locate four major constellations in the northern sky?

Focus on Earth Science Review and Reinforcement Guide
23:1 - Radiant Energy and Telescopes
23:2 - The Electromagnetic Spectrum and Earth's Atmosphere
23:3 - Light Travel Times and Earth History
23:4 - The H-R Diagram

Additional Suggestions:
Study Questions A, B, C, pages 477-479
Points to Remember, page 477
Words to Use, page 477
How and Why, page 479
More Ideas to Explore, page 479

Films:
2449 - Constellations, Guide to the Night Sky
L5116 - The Story of Palomar

NASA Films:
HQ220 - The Universe (28 minutes)
HQ226 - Who's Out There (28 minutes)
HQ245 - Life Beyond Earth and the Mind of Man (27 minutes)
HQ219 - A Man's Reach Should Exceed His Grasp (23-1/2 minutes)
HQ281 - HEAD - The New Universe (19-1/2 minutes)

PERFORMANCE OBJECTIVES	SUGGESTED ACTIVITIES
The student will --	
Identify astronomers Ptolemy, Copernicus, Galileo, Kepler, and Brahe and associate them with their contributions to astronomy.	Have students illustrate the elliptical orbits of matter in space. See the activity on page 462 of the textbook. Have the students use the textbook and make a chart listing the contributions of these men. Students could make posters on the early concepts of our solar system. These could be displayed in sequence to show how our ideas of the universe have progressed through the age. @ The students could do skits on their interpretation of how these men lived, what types of tools they used, and why their ideas were sometimes rejected. Have students do Ptolemy's Circle. The activity is in this guide.
Identify and explain the function of the optical telescope, spectroscope, and Schmidt telescope.	Have students use books and reference sources in the library to look up observatories, telescopes, and write a report. Reports should include the location of larger light-gathering and radio telescopes, the advantages of multiple mirror telescopes, and why so many observatories are being built in unpopulated areas. Have students locate all observatories in Texas. Those who have been to the observatory could talk to the class about their experience. Have students make a simple telescope by following the instructions included in this guide. Arrange to borrow a Goldman telescope (60mm refractor with power up to 150) from the Burke Baker Planetarium. For telescope information and reservations, call (713) 526-4273 or write: Burke Baker Planetarium Houston Museum of Natural Science P.O. Box 8175 Houston, Texas 77004

PERFORMANCE OBJECTIVES	SUGGESTED ACTIVITIES
The student will --	
Recognize types of knowledge gained about the Universe through the study of radiant energy.	Students could make a simple spectroscope and observe some spectra with it. See the activity "spectroscope" included in this guide. Have students do Skillcard No. 6 - Composition of Stars. This activity demonstrates that elements burn with characteristic colors. By using a spectroscope the composition of stars can be determined. Students could list the different types of radiant energy and indicate which has the longest wave length and which has the shortest wave length. (Use a prism to separate light into the spectrum.) Do the activity on page 468 to study the spectrum. Define light year. Use the speed of light to compute the distance that light will travel in one year. @ Students could determine the frequency of waves. See the Extensions to Activity on page 189 of the Activity Book. Students could do the following exercises found in the Review Guide: a. 23:1 - Radiant Energy and Telescopes, page 113 b. 23:2 - The Electromagnetic Spectrum and Earth's Atmosphere, page 114 c. 23:3 - Light Travel Times and Earth History, page 115
Explain what galaxies are and how they are classified.	Define galaxies. @ A few students could do research on when and how galaxies were formed. Give students copies of "Shapes of Galaxies," page 130 of the Astronomy Guide. Have students list and describe the three types of galaxies.

PERFORMANCE OBJECTIVES	SUGGESTED ACTIVITIES
The student will --	*Students could make models of the three basic types of galaxies using styrofoam, cotton, and other materials. Do Making Sure, Nos. 5 and 6, page 472 of the textbook.
Distinguish stars from other celestial objects.	@ Have students do "Information from Starlight" included in this guide. *Skill No. 3 - Light from Stars. A very simple Activity. Skillcard No. 7 - Parallax. This should be a very interesting and simple activity to explain a difficult concept. *Make models of the stars out of styrofoam or papier-mache. (Note: Students should realize that stars are basically spherical, they are made of gases; they vary greatly in size and temperature, and that the sun is just an average star. Activities in the HISD Astronomy Guide tell students how to identify nebulae, giants, supergiants, novae, hot stars, cooler stars, etc. These activities are found in "Star Gazing," Chapter 5, pages 99-123. The Astronomy Guide, Chapter 6 - "Stars and Stellar Evolution," pages 124-132, contains the following information: @ a. detailed data on the sun, pp. 125-126 b. definitions of various kinds of stars, p. 127 c. star brightness (absolute and apparent magnitude) and temperature - pp. 127-128 d. stages of evolution - p. 129 @ e. information about pulsars, quasars, black holes, antimatter, and the universe, open or closed, pp. 131-132 *Students can make charts or posters classifying the stars according to color, temperature, size, and stage of evolution. To build up interest, tell about Betelguese, the red giant.

PERFORMANCE OBJECTIVES	SUGGESTED ACTIVITIES
The student will --	@ Devise a graph for mapping certain stars by their temperature and brightness. Use the temperature color chart and table of information about stars in this guide to determine the location of certain stars. *Demonstrate to students the colors that occur in stars are associated with temperature by carefully heating a piece of wire until it glows. At first it will glow orange, and then yellow as it becomes hotter. Extremely hot wires glow yellow-white. Students should do Lab No. 75, page 189 of the Lab Manual. In this activity students will classify stars based on color. Have students do exercise 23:4 - The H-R Diagram, page 116 of the Review Guide.
Point out and name some major constellations and explain how they are named.	Students could do Lab No. 71 - Refraction of Light. This activity shows how the earth's atmosphere distorts our view of outer space. Monthly star charts could be displayed on bulletin boards. Copies of star charts could also be distributed to students. Star charts for each month can be found in HISD Astronomy Guide, pages 4-15. Distribute copies of (1) Star Gazing - General Information, (2) Construction of a Star Clock, (3) Instructions for Assembling Star Charts, on pages 86-88 in Astronomy Guide. Have students use star chart to locate and point out some constellations. Assign each student a constellation to read about and give a one-minute report to the class. Stories about the constellations are fascinating. Most students would enjoy reporting on the mythological tales of Orion, the Hunter; Hercules; and other Greek heroes.

PERFORMANCE OBJECTIVES	SUGGESTED ACTIVITIES
The student will --	Conduct a class discussion on the Information in Chapter 7 - Astronomy Guide - pages 133-144. Chapter 7 includes: a. What the Star of Bethlehem Might Have Been b. Are we alone? c. What is the Role of Science? Identify any new equipment being used and developed. Read Focus on Frontiers, page 476 of the textbook. Let a student telephone the planetarium and ask them to send information on services available.

Library assignment on scientists and their fields: (1) prepare a paragraph (2) make a one-minute oral presentation.

ANCIENT SCIENCE:

1. Ptolemy-astronomy

15TH-16TH CENTURY:

2. Tycho Brahe-astronomy
3. Nicolaus Copernicus-astronomy

17TH CENTURY:

4. Sir Isaac Newton-astronomy
5. Galileo-astronomy
6. Johannes Kepler-astronomy

18TH CENTURY:

7. Edmund Halley-astronomy
8. Gabriel Daniel Fahrenheit-physics
9. Alessandro Volta-physics
10. James Hutton-earth science
11. Benjamin Franklin-technology

19TH CENTURY:

12. Sir John Frederick Herschel-astronomy
13. Edward Charles Pickering-astronomy
14. Michael Faraday-physics
15. Wm. Thompson Kelvin-physics
16. Andre Marie Ampere-physics
17. George Simon Ohm-physics
18. Robert Wilhelm Bunsen-chemistry
19. Baron Alexander von Humboldt-earth science
20. Alfred Bernhard Nobel-technology
21. Alexander Graham Bell-technology
22. Charles Goodyear-technology
23. George Westinghouse-technology

20TH CENTURY

24. Edward Emerson Barnard-astronomy
25. Edwin Powell Hubble-astronomy
26. Niels Bohr-physics
27. Albert Einstein-physics
28. Wolfgang Pauli-physics
29. Sydney Chapman-earth science
30. Arthur Holmes-earth science
31. Sir Harold Jeffreys-earth science
32. Auguste Piccard-earth science
33. Felix Andries Vening Meinesz-earth science
34. Alfred Lothar Wegener-earth science
35. Walter Maurice Elsasser-earth science
36. William Maurice Ewing-earth science
37. Yuri Gagarin-technology
38. Thomas Alva Edison-technology
39. Robert Hutchings Goddard-technology
40. Charles Lindbergh-technology
41. Wernher Von Braun-technology
42. Wilber and Orville Wright-technology
43. Jacques Cousteau-Oceanography

NAME _____ Period _____ Date _____

Experiment _____: Ptolemy's Circles

Problem: To show the kind of movement which Ptolemy demonstrated to account for the planets' observed paths in the sky

Materials: Bicycle or small wheel

Procedure:

1. Outdoors, roll or ride a bicycle around a circular path. Mark the path on the ground. (Indoors, roll a small wheel on the floor.)

2. Note the movement of the bicycle wheel as the bicycle travels in a large circle.

3. In your notebook, draw a path that describes the movement of the wheel itself as the bicycle moves forward.

Observations:

1. Draw the movement below.

2. What happens as the bicycle moves in the large circle?

Conclusion:

1. What are the two motions of the bicycle?

2. Why do planets seem to move backward as the wheel appears to do?

3. Why do stars seem to remain fixed in the sky?

Name _____ Period _____ Date _____

Experiment: _____ Spectroscope

Purpose: To make a simple spectroscope and observe some spectra with it.

Background: The spectroscope is an instrument that splits light into its separate wavelengths and colors.

Materials: A diffraction grating replica in a cardboard ready-mount

Procedure:

1. Point the slit of the spectroscope at an incandescent (tungsten filament) lamp. Hold the grating close to your eye and look through it.

   Describe the spectrum you see. (Is it a continuous spectrum or a brightline spectrum? What colors does it have? What order are they in?)

2. Examine the spectrum of a fluorescent lamp. Describe it.

3. Examine the spectrum of daylight by looking out the window (but not at the sun). Describe it.

4. Examine the spectrum of sodium as follows:

   Light a Bunsen burner. Make its flame colorless.
   One member of the class holds a crystal of salt in the flame with a pair of crucible tongs. Describe the spectrum.

5. Examine the spectra of glowing gas tubes if they are available in school (neon, hydrogen, sodium vapor, mercury vapor).

Conclusion:

The spectroscope shows that light is usually made up of _____.

The spectrum of a glowing metal such as tungsten is a _____ spectrum. The spectrum of a glowing gas such as sodium vapor, neon, and mercury vapor is a _____ spectrum. The spectrum of sunlight (daylight) is _____ because there are many different materials in the sun.

ACTIVITY TWENTY-FIVE: INFORMATION FROM STARLIGHT

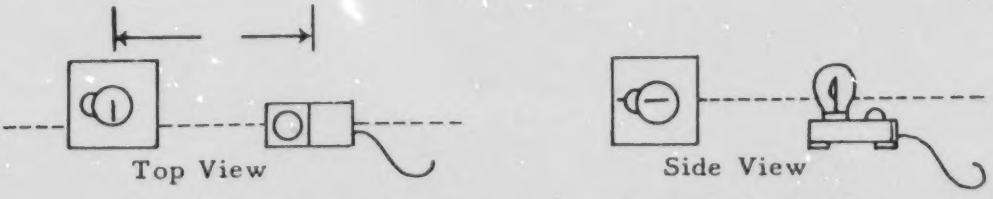
(This data sheet is designed to be used with the pippenblooper but may be modified to fit the light meter.)

To the student:

Plug the light detector (a phototube) into the pippenblooper and point it at the room lights. How many pips per bloop do you observe? Now point it down at the desk. What do you observe? Cover the phototube with your hand: what happens? Which side of the tube is sensitive to light?

Set up a light bulb with an aluminum foil box around it. Cut a 3/8 inch hole in the box at the same height as the light bulb and the pippenblooper light detector. The light bulb will be our star, and the box will prevent light from our star from bothering other groups.

Place the pippenblooper 10 or 15 cm from the "star." (Since the hot light emitting part of our "star" (the light bulb) is down in the middle of the bulb, the measurement must be made from this point even though the hole in the box is quite a bit closer to the pippenblooper.



Measure the intensity of the light striking your pippenblooper at distances of 10 cm, 15cm, and several other points out to about 50 or 60 cm. Make a table relating the light intensity you observed to the distance from the light source.

Put your table on the board so that your teacher may use it during the class discussion of the results of this activity.

Distance	Light Intensity (pips/bloop)

Did you correct your data by subtracting the background room light? How many pips/bloop are caused by the room light?

Repeat the activity for a different-sized lightbulb. Graph your data.

Suppose a lightbulb caused 10 pips/bloop. How far away would the lightbulb be? (Use your graph.) _____

What are the problems in using this method to measure distance? _____

_____

ACTIVITY TWENTY-FIVE: INFORMATION FROM STARLIGHT

NOTE: It may be necessary to review the use of the pippenblooper as a light measuring instrument before beginning this experiment.

WHAT YOU WILL NEED:

Light bulbs (40, 60, or 75 watts) and sockets
Aluminum foil
Meter sticks
Pippenbloopers with phototubes
Special series-circuit outlet box
Spectroscopes (same as used in 9th grade course)
Bunsen burner, nichrome wire for the flame test and any (or all) of the following salts: calcium chloride, copper chloride, potassium chloride, sodium chloride.

(Part I can be done in an ordinary classroom if electrical outlets are available. Part II must be done in the laboratory.)

HOW TO GET STARTED:

We have studied the moon and planets (the solar system) and examples of the processes used by astronomers to gain information. How can astronomers discover information about the stars? Most stars are so far away that their distance cannot be measured by triangulations (sightings). (It is possible to measure the distance of a few of the nearer stars by using the diameter of the earth's orbit as a baseline. How can we discover anything about the stars when all we have is the light which comes to us from them?

Fortunately, starlight carries many messages which can be "decoded." To begin with, the light itself can give us some idea of how far away the star is.

OBJECTIVES:

Most students should be able to graph measured distance vs. illumination data and read predicted values from this graph. All students should be able to explain that this variation is with the inverse square of the distance. Students should be able to use colored pencils or crayons to sketch the spectrum of white light. They should be able to give evidence that they have some understanding of how the spectral distribution varies with the original brightness of a star by sketching the spectrum of a "hot star" and of a "cool star." Finally, they should be able to sketch some of the prominent spectral lines emitted when common salts are heated.

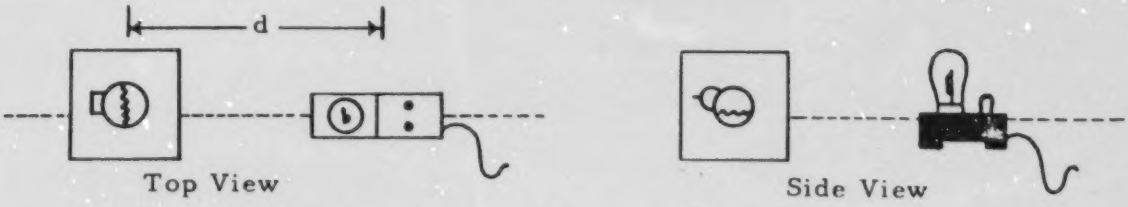
THE ACTIVITY:

Part I. (Instructions to Students)

Plug the light detector (a phototube) into the pippenblooper and point it at the room lights. How many pips bloop do you observe? Now point it down to the desk. What do you observe now? Cover the phototube with your hand. What happens? Which side of the tube is sensitive to light?

Set up a light bulb with an aluminum foil box around it. Cut a 3/8 inch hole in the box at the same height as the light bulb and the pippenblooper light detector. The light bulb will be our "star" and the box will keep its light from bothering other groups.

Place the pippenblooper 10 or 15 cm from the "star." (Since the hot light emitting part of our "star" (the light bulb) is down in the middle of the bulb, the measurement must be made from this point even though the hole in the box is quite a bit closer to the pippenblooper.)



Measure the intensity of the light striking your pippenblooper at distances of 10 cm, 15 cm, 30 cm, and several other points out to about 50 or 60 cm. Make a table relating the light intensity you observed to the distance from the light source.

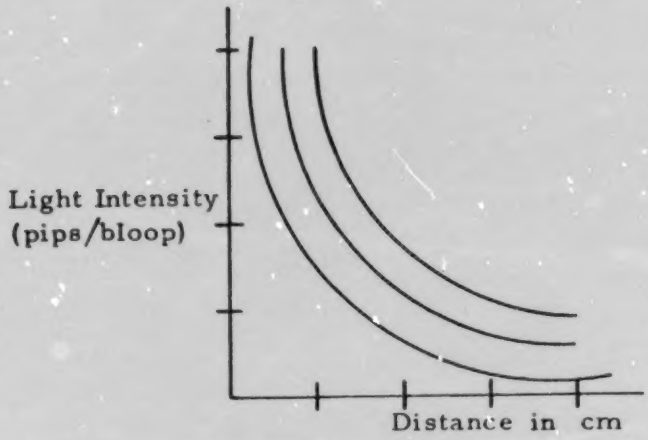
Put your table on the board so that your teacher may use it during the class discussion of the results of this experiment.

Distance	Light intensity (pips/bloop)

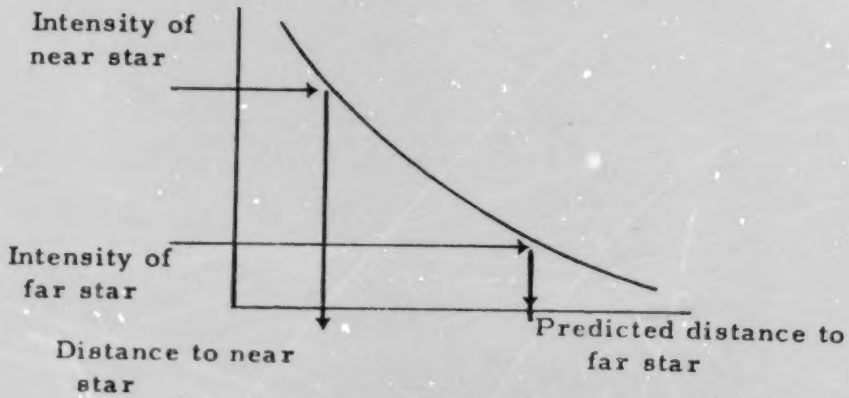
Did you correct your data by subtracting the background room light? How many pips/bloop are caused by the room light?

Discussing the Data: (Class as a whole the next day)

Using a transparency graph, plot each group's data as a separate line on the same graph. If the groups used a fair amount of care, and different wattage light bulbs, a family of curves of about the same shape will result, with the position of the curve determined by the brightness of the "star."



At this point it would be a simple job to determine the distance to a far star, if we only know the distance to a near star of the same brightness.



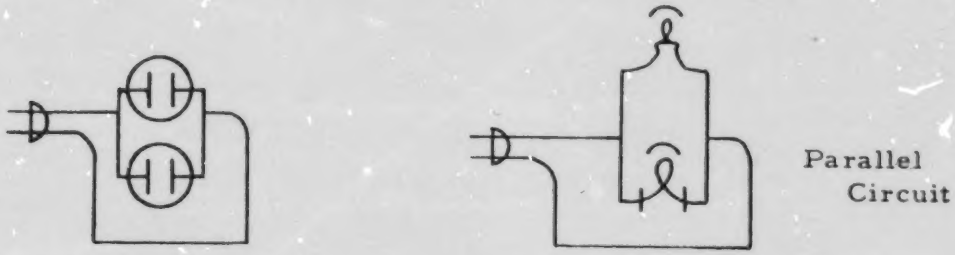
BUT, ARE ALL STARS THE SAME BRIGHTNESS?

The problem with our previous data is that we cannot be sure which curve to use, because each size or light bulb and star will have its own curve. How can one tell whether a far star is of the same size and gives off the same amount of light as a selected near star? A demonstration wil help answer this.

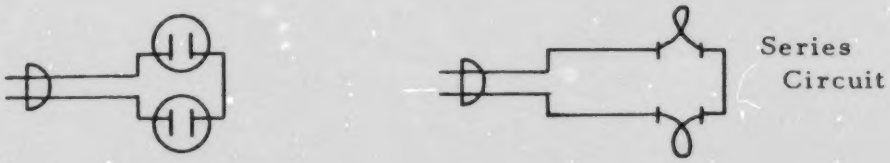
A good clue to the size and brightness of a star is the color of the light it gives off. Scientists can look at the colors of light given off by a glowing object with an instrument called a spectroscope. Simple spectroscopes may be used to see if there is a relationship between the size and brightness of a star and the colors of light it produces.

To investigate this relationship, let us see if there is any difference between the colors of light given off by a "hot" or "cool" light bulb.

It is possible to dim a light bulb either by connecting it to a variable transformer or by wiring another light bulb in series with it. Variable transformers will probably not be available and light bulbs are inexpensive. However, we will need a special extension cord to connect the two bulbs in series. Most two-outlet sockets are wired as shown in the sketch below:



However, if one breaks the connection between the two plugs on one side, and connects the wires as shown in the following figure, the circuit will be complete only when two bulbs are plugged in, and the electricity must flow through both of the bulbs.



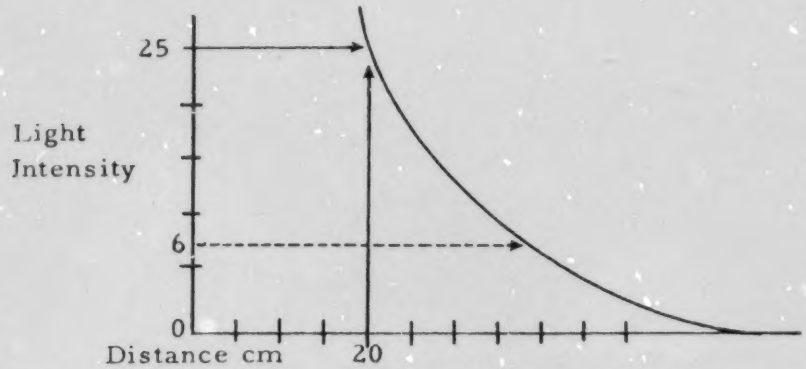
One can vary the temperature or brightness of a 100 watt bulb representing the star by connecting different wattage light bulbs in series with the "star" bulb. Varying degrees of brightness can be obtained by using 150 watt, 100 watt, 50 watt, and 25 watt bulbs in series.

Observe the spectrum of the 100 watt light bulb through the spectroscope. Now decrease its brightness by connecting progressively smaller bulbs in series. Do you observe anything that would indicate that the brightness or temperature of the light source (star) has an effect on the colors of light given off?

> (The cooler the star, the "redder" the light. Note that the blue colors disappear from the spectrum as the source becomes cooler.)

By finding two stars that give off the same colors of light, we can be quite sure that they are about the same temperature and therefore about the same brightness.

Now, let's put what we've learned to work. Let's suppose that we have a "near star" that gives 25 pips/bloop of light when it is at a distance of 20cm from our detector. Suppose that a "far star" has been found to give off the same colors of light as our "near star," so that we can assume them to be of about equivalent temperature and brightness. Suppose that the far star gave six pips/bloop of light at our detector. How far away do you think it is?



Astronomers often use a little quicker system for our graphs for finding distance. Look at your data for light intensity when the "star" was close to the pippenblooper. Now pick a distance just three times as far away. What fraction of the original light intensity is measured here? Can you draw a generalization?

> The inverse square law describes the transfer or propogation of light through space when no reflection of absorption is involved. This law says that the intensity is proportional to the reciprocal of the distance squared; in other words, if one doubles the distance, the intensity should fall to $1/2^2$, or 1/4 of the original value. Tripling the distance would result in a reduction to 1/9 of the original light level.

Part II.

What else can we find out from starlight? The spectra we just looked at also give clues as composition of stars. Use a tiny loop of nichrome wire to hold a crystal in the flame of the Bunsen burner. Look at the light through a spectroscope. What do you see? Try some different salts. Record your observations (you may want to use a table like the one below).

Substance	Colors
Table salt (sodium chloride)	

Do you see that different substances cause different colors of light to be emitted when the substances are heated? Knowing colors are associated with substances, the astronomer can look at starlight and get a good indication not only about the temperature of the star but about the kinds of substances which the star contains.

The flame test can be used to identify elements. However, the study of elements and compounds (even the determination that there are such things) is a part of the ninth grade science course. Therefore, we have tried to avoid any reference in this activity to an element or to a compound. We should be content with the idea that different kinds of substances give off different spectra, without identifying those different substances as being elements or compounds! In a source like the stars or the sun, the parts of the spectra that are missing may really be more noticeable than the parts of the spectra that are there. Nevertheless, by the time this activity is finished, the student should have some very general ideas about how different things can be learned from starlight when that light is broken into its component parts.

Name_____ Period_____ Date_____

Experiment:_____ Constellation Patterns

Purpose: To study a simple star chart of some of the more familiar constellations.

To observe and become familiar with the stars' actual positions in the night sky.

Materials:
- Cardboard
- Glue or paste
- Straight pin
- Scissors

Procedure:

Mount the star chart on the following page on cardboard. Using a straight pin, punch tiny holes through the star chart and the cardboard. Hold the chart up to the light and observe the forms which the stars take. Note that the two stars which make the edge of the big dipper point to polaris, the north star. Polaris is also the last star in the handle of the little dipper.

Questions:

1. What is another name for the north star?

2. What is the name of the last star in the Little Dipper's handle?

3. Do stars actually move? Explain your answer.

4. Do the pointers of the Big Dipper always point to Polaris?

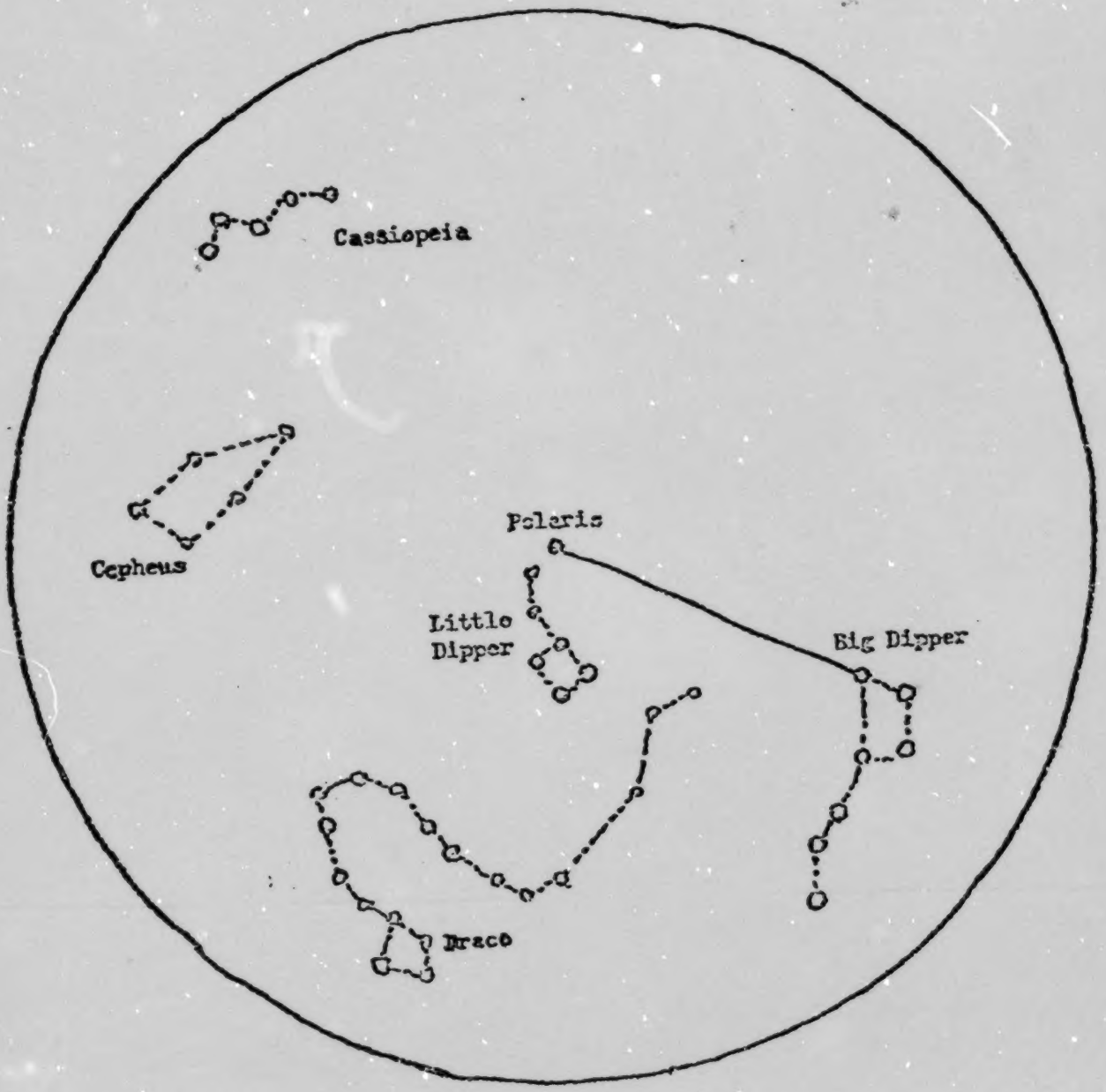
5. Define "CIRCUMPOLAR."

Conclusions:

1. Would the relationship of Polaris to the horizon be the same for a person in Louisiana as for a person in Montreal, Canada? Support your answer.

2. Under the same conditions for these two people, would the constellations have the same relation to Polaris? Support your answer.

3. If you flew over the North Pole, would the constellations have the same relation to Polaris? Support your answer.



Name _____ Period _____ Date _____

Experiment: _____ The Refracting Telescope

Purpose: To show what a refracting telescope consists of by making a simple one

Materials:
A half-meter stick
2 lens holders
1 screen holder that fits the stick
1 convex lens of short focal length (about 5 to 10 centimeters)
1 convex lens of longer focal length (about 20 to 40 centimeters)
Cardboard screen with a central translucent "window" at least one inch square
1 ring stand
1 burette clamp to hold the half-meter stick
2 meter stick holders

Background:

The refracting telescope used by astronomers includes an objective lens and an eyepiece lens. The objective lens is used to form an image of a distant object under observation. To the unaided eye, this image is usually very small, so an eyepiece is used to magnify it for the viewer.

The focal length of a convex lens is simply defined as the distance from the center of the lens to its focus--the point at which a set of parallel rays passing through the lens converge. It can be found easily by using the lens to form a sharp image of a distant object on a screen, since all the rays from a distant object are practically parallel to each other. The distance between the center of the lens and the center of the image is equal to the focal length of the lens.

Procedure One:

Finding the Focal Length of Each Lens

Mount the half-meter stick on the ring stand with the burette clamp. Mount the screen near the center of the stick. Taking one lens at a time, find the focal length of each lens by the method suggested in the last paragraph of the Background.

Focal length of the first lens _____ cm.

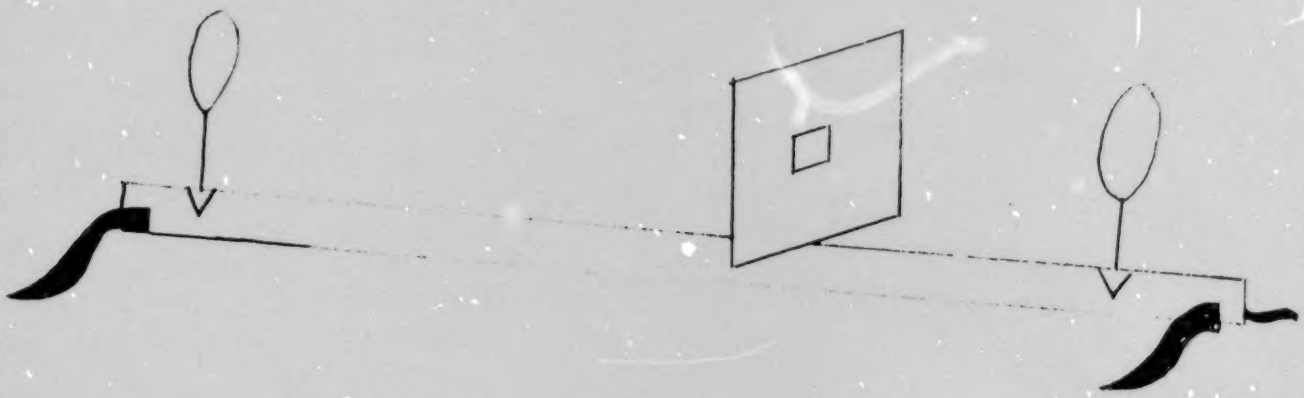
Focal length of second lens _____ cm.

Procedure Two:

Setting Up the Telescope

Using the lens of longer focal length, form a sharp image of a distant object (building, tree, window) on the screen. Now mount the other lens on the opposite side of the screen and use it as an eyepiece, sliding it along the stick to the point where you can see the image clearly. Measure the distance from the eyepiece to the screen. Record this.

Distance from eyepiece to the screen: _____ cm.



Observations:

1. How does this distance compare with the focal length of the same lens?

_____

_____

2. What change does the eyepiece make in the appearance of the image?

_____

_____

3. Without changing the positions of the lenses, remove the screen from the stick and look through the eyepiece again. Explain why you can still see the image.

_____

_____

Procedure Three:

Repeat procedure two but this time reverse the arrangement, using the short-focus lens as the objective to form the image, and the long-focus lens as the eyepiece.

Observation:

4. Is this arrangement better or poorer than the arrangement in procedure one? Why?

_____

_____

Conclusions:

1. The refracting telescope usually consists of an objective lens with a relatively _____ focal length and an eyepiece lens with a _____ focal length. The image is _____ by the eyepiece.

2. When a telescope is used as a camera, the eyepiece is removed and film is placed in the telescope. Where should the film be located?

_____

3. Explain your answer.

_____

_____

Chapter 24: The Solar System

(Suggested Time: 5 days - One Semester)
10 days - Two Semesters)

Major Concepts to be Taught

The motions and properties of the bodies of the solar system

Essential Learner Outcomes

The student will -

- Compare a planet with a star.
- Given the fact that the sun is an average-sized star, explain why it appears to us as the largest and hottest star.
- List at least two conditions that exist on planet Earth that enables life as we know it to exist.

Instructional Objectives

The student should be able to:

- Relate our solar system to our galaxy, the Milky Way.
- Explain how we learn about celestial objects in space.
e . Describe how radiant energy is emitted by the sun.
- Compare and contrast the sun's photosphere, chromosphere, corona, sunspots, solar prominences, solar flares and auroras.
B . Identify and differentiate between the members of the solar system.

Assessments

The student will:

- *Name the small family to which the earth belongs.
e . Explain why if everything in the universe is in motion, the stars seem to be stationary and planets moving.
e . Give the name the early astronomers called all of the planets.
@ . Show how to use a celestial sphere to plot the movement of stars.
@ . Locate on the celestial sphere and define: celestial poles, celestial equator, declination, ascension, elliptic, constellations, zodiac.
- *Name the two gases of which the sun is mainly composed.
- Define and briefly describe transmutation.

*Name a comparable man-made form of energy that resembles the energy production process of the sun.

- Define or explain: photosphere, chromosphere, corona, magnetic poles, auroras, sunspots, solar flares.
- *Explain how we know the sun rotates on its axis.
- *Write the average number of miles the earth is from the sun.
- Describe how the inner and outer planets differ.
- Name the nine planets in the solar system.
- List some of the major discoveries made by space probers of the planets.
- *Name and describe the materials that orbit the sun between Mars and Jupiter.
- Explain the difference between meteoroids, meteors, and meteorites.
- List the materials that make up comets.
- Explain why the tail of a comet always points away from the sun.
- Give the proper term for moon (satellite).
- Name any four planets and tell whether or not they have moons, and if so, how many.

Materials

Textbook: Focus on Earth Science, pages 480-499

Earth Science Skillcards:
- No. 2 - Space and Space Travel - Model of Solar System for Section 22:4-10, page 449
- No. 3 - Space and Space Travel - Orbits of planets for Section 449
- No. 4 - Space and Space Travel - Micrometeorites for Section 22:11, page 461
- No. 20 - Earth in Space - Magnetic Field, Part I for Section 22:4, page 452
- No. 21 - Earth in Space - Magnetic Field, Part II for Section 22:4, page 452

Lab Manual: "Earth Science - A Learning Strategy for the Laboratory"
- No. 74 - Astronomical Distances
- No. 76 - Apparent Sun Motions
- No. 77 - Venus - The Greenhouse Effect
- No. 78 - Jupiter and Its Moons

Earth Science Activity-Centered Program, Teacher's Guide
- Page 194 - Can you trace the movement of sunspots?
- Page 196 - How does collision affect temperature?
- Page 199 - Extensions to Activity 24-2

Focus on Earth Science Review and Reinforcement Guide
- 24:1 - Planet Names, page 117
- 24:2 - The Interiors of Earth and Jupiter, page 118
- 24:3 - Revolution of the Milky Way and Earth's History, page 120

Additional Suggestions:
- Study questions A, B, C, pages 497-499
- Points to Remember, page 497
- Words to Use, page 497
- How and Why, page 499

- More Ideas to Explore, page 499
- Skits on early astronomers
- "Silent Sentinels of Stonehenge," pages 151-152 (Astronomy Guide)
- "Making Sundials," pages 170-181 (Astronomy Guide)

Astronomy Guide, pages 29-52:

- Solar System Information, pages 29-35
- Meteors and Meteorites, pages 36-37
- Mobile Assembly of Solar System, pages 38-40
- Solar System Data Analysis, pages 41-45
- Solar System Slide Rule, pages 46-48
- Mars Close-up, page 49
- Solar System Scale Models, pages 50-52
- Observing Planets, pages 53-58

Films:

M5855 - Mars Minus Myths (1973) 18 Min.
L5190 - Exploring the Planets (1970) 24 Min.
L1674 - Our Mr. Sun - Parts I and II
L5415 - The Active Sun

The following list is representative of what can be borrowed from NASA:

HQ 263 - Mars - Is There Life? 14 Minutes
HQ 264 - Mars and Beyond? 14 Minutes
HQ 266 - Viking - 28 Minutes
HQ 243 - Jupiter Odyssey - 28 Minutes
HQ 236 - Mars - The Search Begins - 28-1/2 Minutes
HQ 223 - Blue Planet - 10-1/2 Minutes
HQ 234 - Our Solar System - 4-1/2 Minutes
HQ 235 - Earth-Sun Relationship - 6 Minutes

PERFORMANCE OBJECTIVES	SUGGESTED ACTIVITIES
The student will -- Relate our solar system to our galaxy, the Milky Way.	Students could do exercise 24:3 - Revolution of the Milky Way and Earth's History, page 120 of the Review Guide. *Students could make a model of the Milky Way using styrofoam, cotton, and other materials. On the model, locate our solar system. Show students film on Mount Palomar. Give students copies of pages 122-123 in the Astronomy Guide. Students will observe different objects in the Milky Way, and also compare the Milky Galaxy to the Andromeda Galaxy. Describe the appearance of the Milky Way in the nighttime sky and ask how many students have seen it. Remind students who will be away from the city lights to observe the night sky and find the Milky Way. Let students compare the diameter of the solar system with the diameter of our galaxy. They will have to convert light years to miles. Students could form two teams debating the pros and cons of life in other galaxies.
Explain how we learn about celestial objects in space.	@ Students could do the activity on page 445 - Ptolemy's Circles. @ Have students do Lab No. 55 - Watch the Sun Go Down. This lab requires daily observation of sun and shadows, sun set and the moon for four weeks. (TIME ELEMENT - FOUR WEEKS) Have students do Lab No. 21, Measuring the Sun's Distance. Film: "Measuring the Universe" Students could make a simple sundial from cardboard. Have students keep records of the accuracy of the sundial. Explain how the sundial works with a flashlight.

PERFORMANCE OBJECTIVES	SUGGESTED ACTIVITIES
The student will --	@ Research Stonehenge or other possible early observatories. Make copies of pages 151-152 "Silent Sentinels of Stonehenge" in Astronomy Guide. *In the Astronomy Guide on pages 170-181 are instructions for making sundials and other instruments.
Describe how radiant energy is emitted by the sun.	Students could view the film, "Our Mr. Sun", Parts I and II, and "The Active Sun." @ Have interested students do research on the hydrogen bomb. *Students could read from the series "What Is" or "How and Why" on the sun and energy. Teacher-made tapes could be made from these readings.
Compare and contrast the sun's photosphere, chromosphere, corona, sunspots, solar prominences, solar flares and auroras.	Skillcards No. 20 and 21 on the earth's magnetic compass. @ Have students do experiment on page 194 of the Activity Book. This experiment requires a minimum one week and a small telescope. Students could define these terms: photosphere, chromosphere, corona, sunspots, solar flares, auroras. Find a simple drawing of the features of the sun and make transparencies to show on the overhead projector; have students make their own drawings. Students could make a bulletin board on the sun. List the mass, density, diameter, rate of rotation, and temperatures. Their diagram of the sun should include these features: photosphere, chromosphere, corona, sunspots, solar flares. Have students do Lab No. 76 - Apparent Sun Motions, page 191 of the Lab Manual.
Identify and differentiate between the members of the solar system.	Skillcard No. 2 - Model of the Solar System. A long but busy activity that students seem to enjoy. There are many ways to modify this lab for each situation. Skillcard No. 3 - Orbits of Planets and Retrograde Motion.

PERFORMANCE OBJECTIVES	SUGGESTED ACTIVITIES
The student will --	Skillcard No. 4 - Micrometeorites. A very interesting activity. Requires outside effort and probably a lot of patience in using the microscope. *Students could make posters showing characteristics of the nine planets. Find the latest information about a planet. National Geographic is a good resource. Compare the periods of rotation and revolution of the earth with those of the planets. Discuss why planets are called "wanderers." Have students do the activity on page 487 of the textbook. Student will determine how planets might have formed. Demonstrate how collision affects temperature. Students could do exercise 24:1 - Planet Names, page 117 of the Review Guide. Do Lab No. 74 - Astronomical Distances, page 187 of the Lab Manual. Review the greenhouse effect as presented in Chapter 8 and do Lab No. 77 - Venus - The Greenhouse Effect. @ Have students speculate as to a typical weather report for the Martian surface on a summer day. Discuss why the earth is unique. Students could do exercise 24:2 - The Interiors of Earth and Jupiter, page 118 of the Review Guide. Have students do Jupiter and Its Moons, Lab No. 78, page 197 of the Lab Manual. Have students do the activity on page 493 of the textbook - The Relative Speeds of Planets. @ Have students compare the force between the earth and moon with the force between the sun and earth. See extensions to the activity, page 199 of the Activity Book.

PERFORMANCE OBJECTIVES	SUGGESTED ACTIVITIES
The student will --	Make a crossword puzzle using the planets of the solar system. *Have students draw and color their own version of each of the nine planets. Students with creative writing ability enjoy making up their own science fiction stories about planets and "people" from outer space, or drawings could be accompanied with a paragraph describing the student's interpretation of the planet's environment. Students could read about meteors. This would be a good time for them to start using the the correct terms meteor and meteorites instead of "shooting stars." Since the discovery of comet Kohoutek much information has been written about comets. Students could even make a simple drawing of the comet's nucleus, head, and tail. Students could do any of the following activities from the Astronomy Guide. These activities are interesting to read, exciting to do and observe: *a. Solar System Information (pages 29-35) *b. Meteors and Meteorites (pages 36-37) *c. Mobile Assembly (pages 38-40) @ d. Solar System Data Analysis (pages 41-45) *e. Solar System Slide Rule (pages 46-48) *f. Mars Close-Up (page 49) *g. Solar System Scale Models (page 50-52) *h. Observing Planets (pages 53-58) The following relationships make good graphs: 1. distance from the sun versus temperature 2. distance from the sun versus length of year 3. distance from the sun versus maximum radio communication time

FORMATION OF PLANETS

PROBLEM: How can planets be formed from eddies in the nebula by comparing the movement of particles on water?

MATERIALS: (List materials)

PROCEDURE:

1. Place two egg beaters in a shallow bowl.
2. Add water to the bowl to cover the webs of the beaters.
3. Gently and evenly distribute some wood shavings on the water.
4. Start one beater in the center of the bowl.
5. Stir slowly and then gradually increase the speed.

OBSERVATION:

1. Notice which shavings move first. Where do they move?

2. What force causes the movement?

3. Do all of the shavings move at the same rate?

4. Does the size of a shaving have any effect on its movement?

5. Stop the beater and observe. Which shavings stop moving first?

PROCEDURE:

1. Resume the beating in the center of the bowl.
2. Have a member of your group start the second beater rotating slowly near the outer edge of the bowl.
3. Alternate the speeds of the beaters.

OBSERVATION:

1. How are the shavings affected by this second movement?
2. How did the alternating speed of the beaters affect the shavings?

CONCLUSION: The chips represented the masses of _____ which formed the _____.

COLLISION AND TEMPERATURE

PROBLEM: To test the relationship between collision and temperature.

MATERIAL: Hammer, sheet metal.

PROCEDURE:
1. Hammer on sheet metal for several minutes.
2. Feel metal and tell what happens.

OBSERVATION: Tell what happens to the metal.

CONCLUSION:
1. What happened to the metal?
2. Why did the temperature change?
3. What theory does this explain?

MEASURING THE SUN'S DISTANCE

Purpose: To "measure" the distance from the earth to the sun with the aid of some simple geometry.

Background: When an image of an object is formed on a screen by a lens, it can be shown by simple geometry (see physics textbooks) that "the size of the object is to the size of the image as the distance of the object (from the screen) is to the distance of the image." In other words:

$$\frac{\text{Size of object}}{\text{Size of image}} = \frac{\text{Distance of object}}{\text{Distance of image}}$$

We may use this relationsahip to find the sun's distance from the earth, provided that we know the other three quantities. In this experiment we form an image of the sun with a lens. We then measure the diameter and distance of the image, which gives us two of the three quantities we need. The third quantity, the diameter of the sun, we know to be 864,000 miles. (To simplify our calculations, we may use 1,000,000 miles as the approximate diameter of the sun.)

Materials: A long-focus lens or small telescope, a small screen or sheet of white cardboard or paper, a ruler (or a half-meter stick, lens holder, screen holder, and screen, as in Exercise 18.)

Procedure:

1. Use the lens to form a sharp, bright image of the sun on the screen. (If the telescope is used, point the objective at the sun, and focus the image on the screen by moving the eyepiece outward a very short distance. Caution: Do not look at the sun either directly or through the telescope! Blindness may result!)

2. As accurately as possible, measure the distance from the center of the lens to the center of the image on the screen to the nearest eighth of an inch (or smaller unit of the ruler).

   Distance of sun's image = _____ inches

3. As accurately as possible, measure the diameter of the image on the screen.

   Diameter of sun's image = _____ inches

4. Using the figures obtained, compute the sun's distance from the following formula:

$$\text{Distance of sun} = \frac{\text{Diameter of sun} \times \text{Distance of sun's image}}{\text{Diameter of sun's image}}$$

$$\text{Distance (in miles)} = \frac{1{,}000{,}000 \times \text{(inches)}}{\text{(inches)}}$$

   Distance of sun = _____ miles

5. If time permits and a lens of different focal length is available, repeat the experiment and compare results.

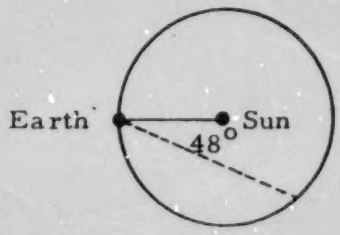
MAKING A SCALE MODEL OF THE SOLAR SYSTEM

To the Student:

Let's make a drawing of the relative sizes of the orbits of the planets just as Johannes Kepler did 300 years ago using observations made by his teacher, Tycho Brahe.

Assume the planets move in circles. Draw a circle 5cm in radius and put a dot at the center. The dot represents the sun, the circle represents the path of the earth, and the 5cm radius, the distance from the earth to the sun. (Kepler didn't know just how far this was, so he called it one astronomical unit.)

Put a dot somewhere on the edge of the circle to represent the earth. Draw a line from the earth to the sun. Tycho Brahe had observed that the biggest angle ever separating the sun and the planet Venus was 48°. Put the center of your protractor on the earth and draw a 48° angle towards the inside of the circle. Your drawing should look something like this sketch:



Can you figure from your drawing where the orbit of Venus must be? Since 5cm = 1 astronomical unit, what is the distance from the sun to Venus in astronomical units?_____

You can draw the orbit of the planet Mercury around the sun in exactly the same way. Kepler knew the greatest angle between Mercury and the sun was 24°. Put the orbit of Mercury on your drawing, just as you did for Venus. What is the distance from the sun to Mercury in astronomical units? _____

How could you construct the orbits of the outside planets? Your teacher can give you some observations for Mars.

What you Will Need:

Compass
Ruler

(Can be done in an ordinary classroom.)

How to Get Started:

This activity may make a little more sense to the students if they have seen the movie "Frames of Reference." If you cannot schedule the movie for the right time, you might try a demonstration which will give them some sort of insight into the types of motions we see when we observe the stars. Make a "V" out of some coat hanger wire and stick a styrofoam ball on both ends of the "V". Now arrange the wire and balls and a light bulb inside a cardboard box so the students can only observe the shadows cast on the wall by the styrofoam balls. Rotate the balls so that one moves around the other. What do the shadows on the wall look like? One should appear to stand still (or nearly so) and the other one should move back and forth. Have the students guess what kind of motion is actually happening inside the box. Hopefully, someone will say it's a pendulum swinging back and forth. Perhaps another student will be observant enough to recognize that it could be simply a shadow projection of rotational motion.

Much the same thing happens when we observe the planets Mercury and Venus in the sky. They appear to move back and forth but we cannot be sure if this is their real motion or only their apparent motion. We can only begin by making a guess. It turns out that guessing circular motion works out very well indeed.

This activity is really a problem in constructing circles. It is a fairly straightforward problem which should not cause much trouble even though you will undoubtedly have to give a lot of individual help to some students to see them through it. Understanding the relative distances by seeing them displayed on a scale drawing will probably be much more valuable to the students than trying to remember the exact values for those distances. Note that if the student tries to put the planets Uranus, Neptune, and Pluto on his scale drawing he will need to stretch the orbits out about 2 meters from the central dot which represents the sun. You can get the orbits for Mercury, Venus, Earth, and Mars onto an ordinary sheet of typing paper without much trouble. However, if you think it is worthwhile for the student to draw in the other orbits, the idea of using old newspapers may be a good one here.

(Obviously, the method for finding the orbit of planets which are farther from the sun that the earth is much more complicated. This is why we have included an example of only one (Mars). For modified classes, you may wish to do that construction on the blackboard instead of having students do it individually. If so, the distance of Mars from the sun can be found in astronomical units, and students can simply draw in the orbit of Mars using the answer you obtained on the blackboard.

Objectives:

Students should be able to draw a circle using a compass. They should know that one astronomical unit is the distance from the sun to the earth and be able to name the two planets whose orbits are between the sun and the earth's orbit. Higher ability students should be able to explain (verbally or by sketch) how observations of angles can give information about the sizes of "circular" orbits.

The Activity:

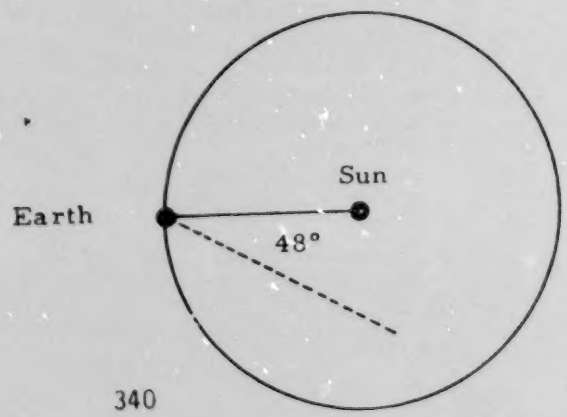
By this time you should know that the type of motion you think you see really depends upon where you stand to observe that motion. For example, what may look like back and forth motion to you could possibly be circular motion. People who watched the skies years and years ago had the problem of determining whether the motions they thought they saw were really the way they appeared. Let's try a little activity

to show them what they saw. Choose two members from the class and let them stand at the front of the room. Have one of these people stand still and let the other person walk around him in a circle. Now while sitting at your desks stretch both of your arms. Point the left hand at the person who is standing still. Move your right arm so that you always point at the person walking as he circles around the person standing still. What kind of motion does your right hand make through the air? What kind of measurements could you make to measure this motion?

More than three hundred years ago, an astronomer by the name of Tycho Brahe measured the same kind of angle your arms made as you pointed to the people at the front of the room. But his observations were made on the sun and the planets that moved back and forth in the sky. Tycho Brahe did not know what kind of motion he was measuring. So he simply wrote down very carefully all the angles that he measured in notebooks and put them aside on a shelf. A few years later his student, Johannes Kepler, made an accurate scale model of the solar system using the measurements of Tycho Brahe. Kepler had to guess that the planets were really moving around the sun in paths that were very close to being circles. This guess is what a scientist calls a hypothesis. Kepler had no way of testing his hypothesis directly, for to do this he would have to get off the earth and look at the solar system from some other place. But he could make enough drawings and do enough work to show that the results of his hypothesis would agree with all the known astronomical facts of his day. If you will follow the instructions below, we will construct a scale drawing of the solar system as Kepler guessed it to be.

Draw a circle 5 cm in radius and put a dot at the center to represent the position of the sun. You ought to think of the circle as the path of the earth around the sun. Put a point somewhere on the circle to represent the earth. Now draw a line from the earth to the sun. How many miles does this line represent? How many miles is it from the earth to the sun? Right now in this lesson you do not know, and neither did Kepler. He called this distance one astronmical unit (1 a.u.).

Now we want to put the orbit of Venus on the drawing. Kepler knew from the observations of Tycho Brahe that the largest angle separating Venus and the sun as observed from the earth was 48°. The picture below will help you if you get mixed up. Put the center of your protractor on the dot which represents the earth and mark off a 48° angle towards the inside of the circle. Can you draw a circular path for Venus around the sun so that Venus can appear 48° from the sun but never any more than that? Note that there is only one possible new circle you can put in your drawing which would represent this path for Venus. Measure the distance from the sun to Venus. Remembering that 5 cm on your drawing is one astronomical unit, try to figure out what part of an astronomical unit represents the distance from Venus to the sun. Write your answer here:_____.



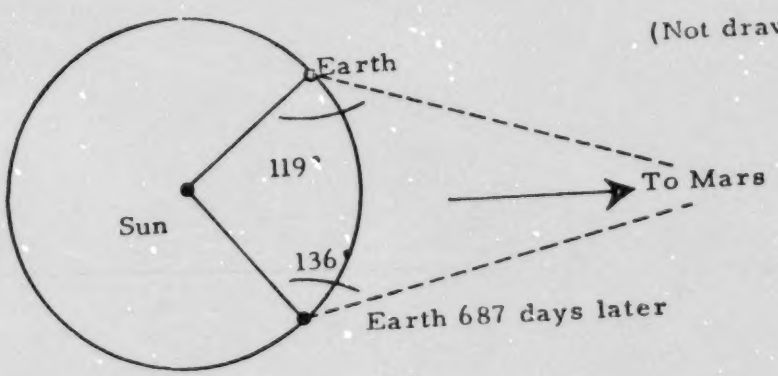
(Not drawn to scale!)

You can draw the orbit of the planet Mercury around the sun in exactly the same way. Kepler knew that the greatest angle between Mercury and the sun as sighted from the earth was 24°. Put the orbit of Mercury on your drawing and measure the distance from the sun to Mercury. How far is this distance in astronomical units? Write your answer here:_____.

****

This method is fine for the planets between the earth and the sun, but what about the planets outside of the earth's orbit? We will construct the orbit of Mars to give you some idea about how they move. It takes the earth 365 days to go once around the sun. That is, wherever Mars is today, it will be back in exactly the same place 687 days from now. But 687 days is 1.88 years. So in this time the earth goes around its orbit 1.88 times. How big is 0.88 of a circle? How many degrees? Make another dot on the earth's orbit to show where the earth is 687 days after the dot you first put on.

Kepler knew that Tycho Brahe had measured the angle between the sun and Mars to be 119° on a certain day. Put this angle on your drawing as the sketch below shows. He also knew that 687 days later Tycho had measured the angle between the sun and Mars to be 136°. Put this angle on the second dot which represents the earth.

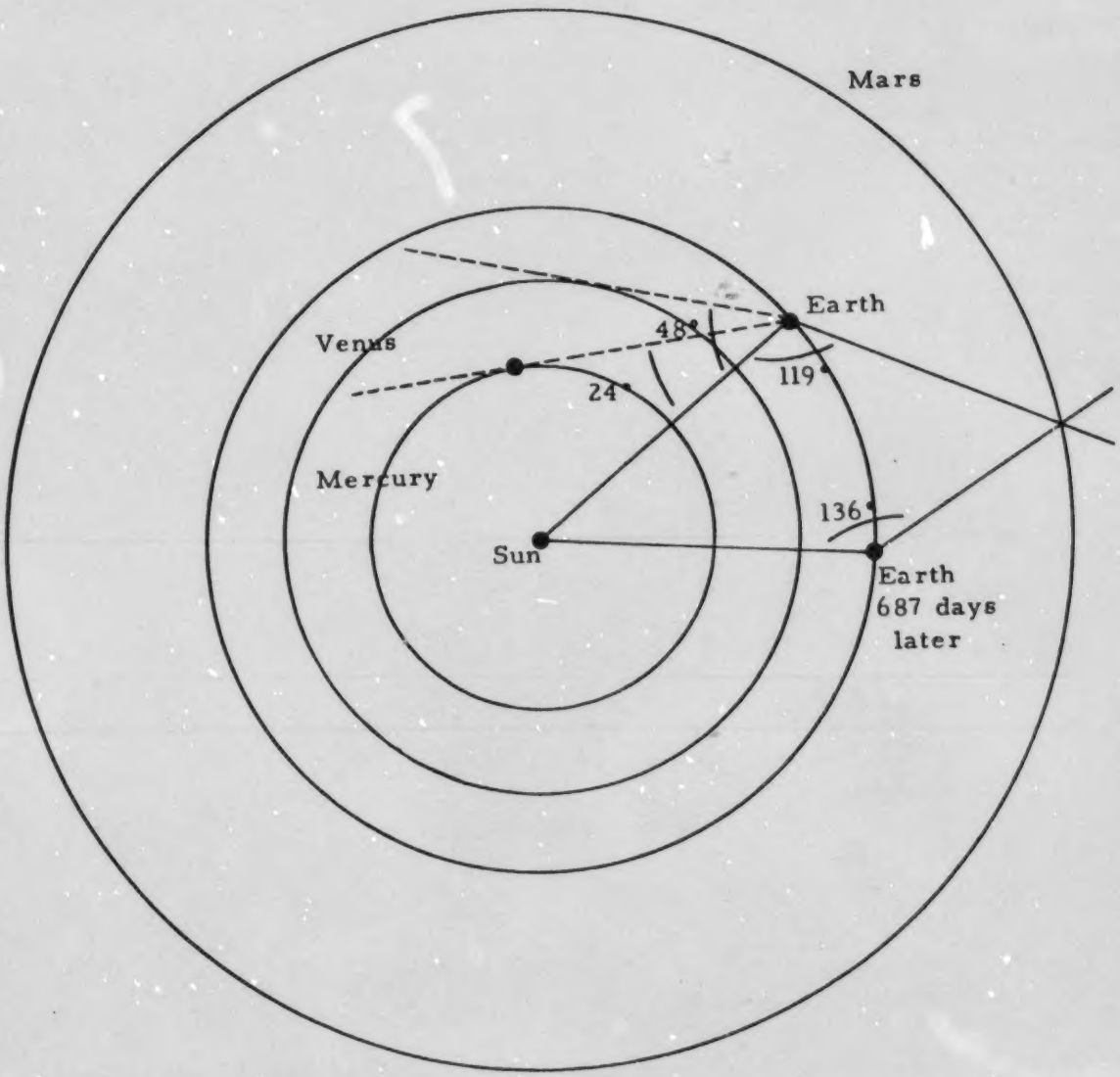


Where, then, is Mars? How far in astronomical units, is Mars from the sun? Write your answer here:_____.

****

Kepler also worked out the positions of Jupiter and Saturn, comparing their distances to the earth's distance from the sun. He found Jupiter to be 5.2 a.u. from the sun and Saturn to be 9.5 a.u. from the sun. He did not suspect any more planets. But now we know that there are three more--Uranus is 19 a.u. from the sun. You may want to tape enough sheets of paper to your drawing to add these orbits too. Of course it will take a lot of paper to draw the entire circle for each orbit, so just make a mark to indicate where the circles would pass across your paper.

This sketch should give you an idea of how your final construction should appear.



Chapter 25: Space Voyage and Exploration

(Suggested Time: 3 days - One Semester)
5 days - Two Semesters)

Major Concepts to be Taught

Space exploration and its history
The present state of space technology and its future

Essential Learner Outcomes

The student will -

- Given a balloon, demonstrate and explain Newton's Third Law of Motion, "For every action, there is an equal and opposite reaction," and explain how this law applies to a rocket lifting off the ground.

Instructional Objectives

The student should be able to:

- explain how Newton's Third Law of Motion applies to a rocket lifting off the ground and list the early pioneers in rocketry.
- describe the event that began the space age and explain the purpose of space probes.
- discuss space frontiers.

Assessment Guidelines

The student will:

- give three examples to explain Newton's Third Law: For every action there is an equal and opposite reaction.
- list three early pioneers in rocketry.
- define satellite and diagram and/or describe possible orbits around Earth.
- describe highlights of the NASA space program.
- explain the purpose of the Apollo Program.
- discuss the advantages and disadvantages of a space shuttle in space exploration.

Materials

Textbook: Focus on Earth Science, pages 500-519

Focus on Earth Science Activity-Centered Program, Teacher's Guide
Page 200 - Extensions to the activity

Focus on Earth Science Review and Reinforcement Guide
25:1 - Viewing a Satellite, page 121
25:2 - Space Colony Problems
25:3 - The Space Program

Films
L5199 - Satellite and Men in Orbit (1970) 24 min.
L5448 - Surviving in Space (1968)
H9221 - Space Expectations - 27 min.
HQ229 - The Time of Apollo - 28 min.

PERFORMANCE OBJECTIVES	SUGGESTED ACTIVITIES
The student will -- Explain how Newton's Third Law of Motion applies to a rocket lifting off the ground, and list the early pioneers in rocketry.	*Skillcard No. 8 - Satellites. Explain how orbits are achieved and how space flight is possible. Have students do "Rockets." This experiment is included in the guide. In this experiment students will find out what makes rockets move. Have students do "Rockets," the activity in this guide. Read about one pioneer and report the findings to the class. Students interested in model rocketry may want to build models.
Describe the event that began the space age and explain the purpose of space probes.	*Students could construct a bulletin board illustrating the history of satellites. Students could report on the lives and work of Dr. Robert Goddard and Dr. Wernher Von Braun. Define satellite and tell who launched the first satellite. Explain why satellites always pass over the earth. Refer students to satellite photographs on page 505. Ask them to give a possible explanation for the cloud patterns that occur over the United States. Do exercise 25:1 - Viewing a Satellite, page 121 in Review Guide. Explain how Comsat saves time. Library research on the Apollo flights. The class could be divided into small groups and each group research one particular flight. (Remember that major advances have been made in technology, medicine, geology, and other fields of science because of the space flights.) Have a debate on the pros and cons of space flights. Students could do "Stranded on the Moon." This activity is included in this guide.

ACTIVITY: ROCKETS

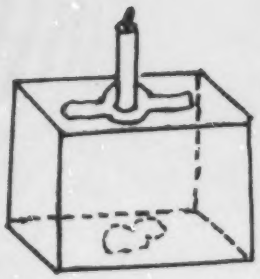
FIND OUT: What makes rockets move?

YOU WILL NEED:

Small aluminum pie pan (13 cm)	1 hole stopper	toy boat
empty tissue box	candle (6 cm)	meter stick
test-tube holder	silicone glue	needle
heat-resistant test tube	stopwatch	tape

heavy-duty aluminum foil (40 cm x 76 cm)

pan or tub of water (longer than 80 cm)



1. Fill the hole of the stopper with silicone glue. A fine needle should be inserted in the glue before it dries in order to retain a tiny opening. Wait twenty-four hours.

2. Enlarge the opening of the tissue box at the center so that you have a circular opening with a diameter of 6.3 centimeters (about 2.5 inches). Cover the tissue box with aluminum foil. To do this, place the box in the center of the sheet of foil. Fold up the foil around the box as you would when wrapping a package. Leave the top exposed. Do not cut or tear the foil, since you want the box to be waterproof. Fasten the foil with tape so that it remains in place.

3. With melted wax attach a candle securely to the bottom of the box as shown in the picture.

4. Cut a circle with a 5-centimeter (about 2 inch) diameter out of the center of the pie pan. Turn the pie pan over. With your finger, make a dent across the center of what's left of the base. Push up a narrow hump on either side of the dent.

5. Fill the test tube full of water. Remove the needle from the glue in the stopper. Close the test tube with the stopper. The test tube should then be cradled between the humps in the pie pan. The "cradle" should be a bit higher at one end than at the other so that the water does not cover the hole in the stopper. Light the candle. Place the "cradle" with the test tube over the candle. Line the "cradle" up so that the test tube will lie straight along the length of the box.

6. Place your "boat" in a pan of water. Tape a meter stick to the long side of the pan. The longer the water area is, the better. Wait for the water in the test tube to be converted to steam. Measure how far your "boat" can travel in a minute. Record the distance in the table.

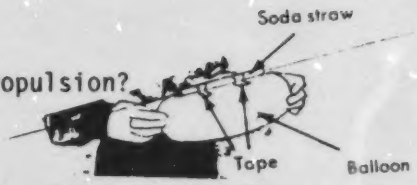
7. In order to compare results, substitute a toy boat for the tissue-box boat. Set up the pie pan and test tube on the toy boat. Record the distance it travels in a minute.

	Distance Traveled (cm)		
	1st Trial	2nd Trial	3rd Trial
Tissue Box			
Toy boat			

MAKING BALLOON ROCKETS

PROBLEM:

How can you show the principle of rocket propulsion?



MATERIALS:

Each group of students will need a balloon, masking tape, scissors, three meters of string, and a drinking straw.

PROCEDURE:

1. Cut the drinking straw in half. Pull the string through one of the halves.

2. Blow up the balloon and hold the end so that the air does not escape.

   Note: Do not tie the end of the balloon!

3. Have someone tape the drinking straw with the string pulled through it to the side of the balloon, as shown in the illustration. Do not let go of the end of the balloon.

4. Have two students pull the string tight between them.

5. Move the balloon along the string to one end of the string. Release the balloon and observe its "flight" toward the other end of the string. How far did the balloon go? Make a chart like the one on this page. Record the distance in the chart. What causes the movement of the balloon? How is this like a real rocket?

6. Repeat the flight of the balloon four times. Measure the distance the balloon goes each time. Record the distances in the chart.

7. Follow your teacher's directions and relaunch your balloon rocket at the same time as all of the other groups release theirs. Did all of the balloons move at the same speed? What variables may have affected the flights of the balloons?

FLIGHT	DISTANCE
1	
2	
3	
4	
5	

Name_____ Period_____ Date_____

Experiment: _____: Stranded on the Moon

Purpose: To acquaint an individual with emergency procedures when confronted in a situation that requires quick thinking.

Materials: Handout - "Stranded on the Moon"

Procedure: Read the directions as given below. Answer the questions that follow.

Instructions:

You are a member of a space crew originally scheduled to rendezvous with a mother ship on the lighted surface of the moon. Due to mechanical difficulties, however, your ship was forced to land at a spot some 200 miles from the rendezvous point. During re-entry and landing, much of the equipment aboard was damaged and, since survival depends on reaching the mother ship, the most critical items available must be chosen for the 200-mile trip. Below are listed the 15 items left available intact and undamaged after landing. Your task is to rank order them in terms of their importance for your crew in allowing them to reach the rendezvous point. Place the number 1 by the most important item, the number 2 by the second most important, and so on through number 15, the least important.

_____ Box of matches

_____ Food concentrate

_____ 50 feet of nylon rope

_____ Portable heating unit

_____ Two .45 caliber pistols

_____ One case dehydrated Pet Milk

_____ Two 100-pound tanks of oxygen

_____ Stellar map (of the moon's constellation)

_____ Life raft

_____ Magnetic compass

_____ 5 gallons of water

_____ Signal flares

_____ First aid kit containing injection needles

_____ Solar-powered FM receiver-transmitter

QUESTIONS:

1. What item did you choose as the most important? _____

   Explain why you chose this item. _____

   _____

2. What item did you choose as the second most important? _____

   Why would this item come second and not first on your list? Explain.

   _____

3. List your top 5 most important items below:

   a. _____ c. _____

   b. _____ d. _____

4. What type of atmosphere does the moon have? _____

   _____.

5. How do the 5 most important items you listed help your situation when considering the atmosphere of the moon? Explain. _____

   _____

   _____

6. Does the moon have any water bodies or oceans that would require the use of a life raft? _____

7. What number was your life raft listed as? _____

8. What 2 items did you list 14th and 15th on your list?

   _____ and _____

9. Why did you decide to list the 15th item last on your list? Explain.

   _____

   _____

Conclusion:

1. After doing this experiment, explain what things you consider most important in sustaining life in an emergency situation.

2. Explain how this type of information could be applied to an emergency situation of today, such as a car wreck, earthquake.

3. What is the most important concept or idea being pointed out in this experiment.

THE MOON--A GIANT LEAP FOR ALL

ACTIVITY: Report on a Science Fiction Short Story

To make this report, you are to pick out a science fiction short story, or if you prefer, a book which tells about space travel, life on another planet, or the future on earth.

First write a summary of the story you have read. The summary is to be at least 3/4 to 1 page long. Don't copy out of the book, but put the story in your own words, no matter how they may sound to you. I am interested in your impressions, and can recognize something you copied from a book jacket. If you copy, you can expect a low grade.

Secondly, pick out as many examples as you can in the story where facts we know about space, space travel, or other planets are used in the fiction story. Also, tell if the author created any science facts to make the story more interesting. You might note any future inventions talked about in the story which help man to deal with the conditions in the solar system, outer space, or here on earth. This should take at least one more page.

Examples:

From "A Martian Odyssey," by Weinbaum, about astronauts on Mars.

> "You know how deceptive sounds are in this thin air. A shot sounds like the pop of a cork..."

In the report, you could write that the story mentions Mars, thin atmosphere, and tells us that sound can't travel well in it because sound needs something to travel through.

> "I finally gave it up and got into my thermo-skin to sleep. The fire hadn't kept me any too warm...I opened it a little and bingo! Some eighty-below-zero air hit my nose, and that's when I got this pleasant little frostbite to add to the bump I got when my rocket crashed..."

You could write that the story mentions the fact that Mars nighttime temperatures drop to -80° F and astronauts must have a thermal protection layer. The temperature can instantly freeze a man's skin.

You might also use descriptions of the surface or atmosphere or the creatures the astronauts found and how the living things had adapted to their special life conditions. Be sure to mention any facts that you know are true about the solar system that the author uses.

The finished paper should be 2 to 4 pages long, written in ink, and written on only one side of the paper.

It is due _____ and will count as a major grade.

To be sure that you have picked a good story, you should show it to me before you start working with it. If you pick the wrong type of story because you didn't consult me, you will make a low grade.

APPENDIX

Bottom Communities of the Upper Texas Coast
(Eulittoral and Intertidal Zones)

Rocky Shores: On the Texas Coast only man-made jetties and piers make possible a habitat for certain species that would not normally occur. The following are most common:

Ishnochiton	Chiton (Port Aransas, south)
Littorina	Periwinkle (snail)
Siphonaria	False Limpit (snail)
Ostrea Equestris	Oyster
Chthamalus	Barnacle (crustacea)
Arbacia punctulata	Sea Urchin (Port Aransas, south)
Bunodosoma	Large Sea Anemone (Coelenterata)
Sagartia	Small Sea Anemone
Membranipora	Encrusting Bryozoa
Ligia	Dock Louse (Crustacea, Isopoda)
Various Tunicates	Sea Squirts
Various Algae	Ulva Common (Port Aransas, south)
	Lithothammion, Calcarious Algae

Loose Rocks and Stones: These generally are not found on the Texas coast.

Intertidal Sand: This zone is a uniform habitat with very few forms on the surface; most are in fauna.

Donax	Coquina Clams
Arca, Anadara	Ark Clams
Mulinia	Dwarf surf Clam
Anatina	Duck Clam
Barnea	Angel Wing
Polinices	Moon Snail
Busycon	Lightning and Pear Whelk
Diopatra	Tube Dwelling Worm
Crepidula	Slipper Snail, Olive Snails
Callianassa	Ghost Shrimp
Emerita	Mole Crab
Ocypode albicans	Ghost Crab
Paranthus	Sea Onion (Sea Anemone)
Luidia	Sea Star
Ophiolepis	Brittle Star
Isocheles, Paguis	Hermit Crabs

Intertidal Mud: In this zone the anaerobic conditions limit the number of species.

Balanoglossus	Acorn Worm (Hemichordate)
Barnea	Angel Wing (2" to 3" deep usually)
Ensis	Razor Clam
Tagelus	False Razor Clam
Volsella	Horse Mussel
Polinices	Moon Snail

Chaetopterous	Parchment Worm
Arenicola	Lug Worm (Polychaete)
Callinectes sapidus	Blue Crab
Clibinarius	Hermit Crab
Penaeus (2 species)	Edible Shrimp
Balanus	Barnacle
Menippe	Stone Crab
Sesarma	Sand Crab
Uca (3 species)	Fiddler Crab
Littorina irrorata	Periwinkle

Estuaries: An estuary is an area in which there is an influx of fresh water at the upper end and both an influx of saline water and an outpouring of diluted sea water at the lower end. The extent of fresh inflow is seasonal and very often is rapid and sporadic. It is here that organisms are subjected to the greatest environmental change, such as salinity, exposure, turbidity, and temperature. However, because of the high organic content of the mud, organisms that can survive the environmental changes occur in large numbers; i.e., 10,000 polychaete worms, 22,000 snails, 1,000 clams per square meter. (Spooner & Moore, 1940). In the more saline areas of our estuaries, the following organisms are abundant.

Balanus	Barnacle
Serpula	Calcarous Tube Dwelling Polychaete
Aiptassimorpha	Small Sea Anemone
Brachiodontes	Hooked Mussels
Pachygrapsus	Flat Crab
Menippe	Stone Crab
Callinectes sapidus	Blue Crab
Uca	Fiddler Crab
Neopanope	Rock Crab
Ostrea virginica	Edible Oyster
Membranipora	Encrusting Bryozoa
Mercenaria	Quahog (clam)
Penaeus	Edible Shrimp
Crangon	Pistol Shrimp
Squilla	Mantis Shrimp
Arinicola	Lugworm
Nereis	Annelid Worm

In the less saline waters of the estuary, the following forms are usually found:

Tagelus	False Razor Clam
* Rangia cuneata	Clam
* Macoma mitchelli	Clam
Palaemonetes	Brackish Water Shrimp
Littoridina	Small Snail associated with Rangia

The above lists include the most common bottom organisms found on the upper Texas Coast.

* These are index species found nowhere else.

Materials Needed for Maintaining Saltwater Aquariums

All glass or plastic tanks or metal bound tanks carefully sealed with "sealastic" to prevent salt water from touching the metal (This material can be secured from any aquarium supply store and should be used to seal the tank according to the directions on the package.)

An air pump and proper filter for each tank

An extra pump with a two gauge valve for emergency purposes (If an animal appears to be in distress or is not getting along with the others in his tank, he might have to be removed quickly. A two-gauge valve supplies two tubes with air from the same pump. In such an emergency, this extra pump can aerate two recovery tanks.)

A thermometer, all glass enclosed, weighted to float (One of these costs about $1.95 at a pet store.)

A hydrometer, which also costs about $2.00 (Some ocean fishes are very sensitive to variations in density. If there is any doubt about the natural enviornment of a specimen, the water in which he was collected should be checked for density.)

A heater for each tank if the room is air-conditioned (Otherwise, one heater should be kept on hand to equalize temperatures when tank changes are made.)

Water (If you catch your own specimens, bring in enough water to check the density. If you use *natural water,* be sure bay fish go into bay water, gulf fish into gulf water. Be careful where you collect your water. Do not collect natural water near large industrial plants, inshore from drilling rigs, or too near harbors and ship roads. Much of the Gulf water at Galveston is subject to pollution. If fish appear to be in distress in natural water and all other conditions seem to be normal, change the water because it is probably polluted. In fact, the water is the most difficult factor to control in keeping marine animals alive.

Artificial water might be used. This costs a little more at first, but by the time you have driven to the bay or the Gulf several times for new water, you may decide the artificial water is cheaper and easier. Make it this way: Place tap water in your tank, leave twenty-four hours before adding salt to allow all chlorine to escape. You can also use distilled water and avoid the twenty-four hour wait, but that runs up the cost. Do not use ice cream salt, "rock" salt, or table salt. There are other necessary minerals present in the special salt. Add the salt to the water slowly, stirring as you add it. Use only a wooden, plastic, or glass spoon – NO METAL! Keep your hands out of the water. One pound of salt to 3 gallons of water will achieve a density of about 1025 by hydrometer. This is the density we use for seahorses, the sargassum fish, and others taken from actual gulf or ocean waters, not bay water. If you are matching bay water with artificial water, use less salt in proportion to the distilled water. Use a hydrometer to obtain the right density.

Distilled water or tap water which has stood for twenty-four hours should be kept on hand. Because of evaporation, salinity will increase constantly until it becomes harmful to the fish. Adding more bay water will also add more salt, so replace evaporated water with fresh water. (If you do not have a hydrometer, be sure to mark a water line on the tank when you first fill it with salt water. When it has evaporated enough that the loss is visible at the water line, add fresh water until the proper level is reached again.)

Dip nets from pet store or sporting goods store (These are for transferring fish from one tank to another and should always be used instead of the hands. If you can find nets with plastic frames and handles, they are best. If you must use metal framed nets, rinse the salt water off carefully each time the net is used. Salt water corrosion of metal is poisonous to the fish.)

Extra bowls or 2 gallon aquariums (There is a 2 gallon rectangular aquarium of molded glass with no metal parts, which is fine. These bowls can serve as emergency tanks if a fish has to be removed from his tank immediately, or if a new specimen is brought in before permanent arrangements for it are made. There will be such contributions from time to time.)

Glass wool and charcoal if that type of filter is used (The wool must be changed occasionally.)

Filters, either the under-sand filter or the box-type filter using charcoal and glass wool (Each type has its advantages. The box-type is easier to set up and change when the water must be changed. It can also use an airstone in the bubbling mechanism to break the air into smaller particles and produce more bubbles. This provides better aeration. The under-sand filter makes a very natural looking tank, and, in a small tank especially, leaves more swimming room.

Pure white sand or aquarium gravel (It is better to use purchased material because it is more likely to be free from newly dead animal matter which will pollute the tank.)

Coral skeletons, sea shells, etc., to decorate the tanks if such material is well aged and free from all animal matter (If there is any doubt, the shells and coral can be soaked in a mild clorox solution for twenty-four hours, rinsed and dried for another twenty-four hours. Do not use shells or coral which have been dyed, no matter how pretty they may be.)

Maintaining a Saltwater Aquarium

Use all glass, all plastic, or sealed tanks, as described in the section listing materials.

Maintain aeration and filter the water by any of the methods used in fresh water tanks.

When a fish is placed in a tank, the new environment should be as much as possible like the old. Temperature and salinity should be as nearly the same as possible. Sudden temperature changes especially are to be avoided.

Most Galveston Bay fish can be kept in a Gulf water environment, but the salinity should be increased over the original salinity gradually over a period of several days. Abrupt changes in density place a strain on the kidneys and circulatory system; the damage is not always readily apparent, but it will take place. Avoid this by adding a little more of the Gulf water each day if you wish to change the salinity.

Do not crowd the aquarium. One or two compatible fishes about two inches long are about right for a five- gallon tank. If the fish are larger than that, one per tank is better. In larger tanks, increase your population in about these proportions. Especially, do not overload the tanks with too many of one species.

Put only compatible fish together. Find out which are live feeders and how large their prey will be. Do not put with these any fish which might be eaten.

In determining compatibility, consider not only size and aggressiveness, but also food needs. It is much easier to care for a tank containing all bottom feeders or one containing all live feeders than to have mixed food needs for one tank.

Be careful not to overfeed. Watch closely to be sure that all the food placed in a tank is cleaned up immediately. Unused food will pollute the water and necessitate changing it in order to avoid poisoning your specimens.

In the event of a power failure, adequate water should be on hand to set up emergency tanks in bowls, etc., in which single fish can be placed. The fewer the fish, the longer they can live without aeration. Many bay fishes can survive several hours in a large bowl of new water.

If the fish in a tank begin to congregate around the bubbler or the airstone, they are probably suffering from lack of oxygen even though the pump is working. Sometimes they look like children around a drinking fountain. When this happens, the tank population should be reduced at once, and a spare airstone from the extra pump dropped into the tank until the oxygen is restored.

Other symptoms of distress are swimming out of balance; colliding with other fish or with the walls of the tank; missing food when attempting to feed; failing to see food; swimming wildly and nervously; being much more sluggish than usual; refusing food. If any of these symptoms occur, the fish should be placed alone in a tank of new water. It might die anyhow, because it has probably sustained nervous system damage already.

Red spots on the bodies of the fish are probably due to injuries from handling. Where scales are knocked off, infection or fungi get a foothold. Isolate such fish.

If the gills, mouth parts, and areas around the eyes become very red, the fish is probably in need of oxygen.

When changing water in a tank suspected of being polluted, be sure to discard the sand and replace it with new sand. If you are using coarse purchased gravel or marble chips, wash them thoroughly before reusing. Sand traps hold rotten matter – stay alert.

Never wash any of the equipment with soap or detergent.

If you have a distressed fish and wish to move it immediately, do not allow your haste to get it into a better environment result in your placing it into water of a different temperature. A variation of a very few degrees in temperature will be more than a fish already in trouble can survive.

A Crab Terrarium

A natural looking environment is needed for hermit crabs and fiddler crabs. A cracked aquarium which cannot be patched to hold water or a plastic tub may be suitable. Fill it to a depth of two to four inches with damp beach sand, making a slope toward one end. In the shallow end, sink the lid of a pyrex dish and fill with water to represent a tide pool.

The fiddler crabs take to their new home with delight and build burrows immediately. The pupils may watch them dig their holes. Some of the burrows may be against a glass side, and the pupils can see the crabs when they "hide" in their hole. They will come out to eat or take a dip in the tide pool, then scurry back to the burrows.

This exhibit is very little trouble to keep after learning how to feed the crabs to keep from fouling the sand with decayed matter. The great temptation is to overfeed, then the unused matter spoils. Observation will tell you how much your crabs will clean up. They like tiny bits of meat (hamburger), shrimp (remove the shell and cut it into small pieces), or hard-boiled egg. Feed egg sparingly and in large enough crumbs to be removed when not used. It is the worst offender in making the tank smell bad.

No matter how careful you are, the tank will have to be changed occasionally because the animals themselves will contaminate the sand with body wastes. Do not worry about destroying the dens – the crabs will build new ones at once. It is best, if possible, to clean tanks out of doors.

Hermit crabs may live in here also. Hermits do better in a regular tank, but they must be aerated just as fish are or they will smother.

SEA ANEMONE

Bottom: May vary; needs some hard surface to attach (rocks, shells, logs)
Filtration System: Filter
Feeding: Frozen Shrimp, occasionally live fish, frozen liver or beef heart
Compatible Organisms: Hermit Crabs, Fish
Aquarium Size: 5 - 15 gallon (may vary according to number of species stocked)
Other: Most interesting to the observer, esp. feeding habits and tentacle movement

FISH (GENERAL)

Bottom: May vary from Sand to Gravel (at least two inches). Some fish like Flounders should have a soft sandy bottom.
Filtration System: Filter
Feeding: Tiny pieces of frozen shrimp; Dried Flakes (Remove uneaten food after 30 minutes)
Compatible Organisms: Depends upon type of fish; Hermit Crabs make good scavengers; no more than two per tank
Aquarium Size: 10 - 29 gallon (larger fish require more surface areas)
Other: 3 - 7 fish/ 15 gallon

GOBIES

Bottom: Sand
Filtration System: Filter
Feeding: Tiny pieces of frozen shrimp
Compatible Organisms: Hermit Crabs; any bottom fish their size
Aquarium Size: 5 gallon
Other: Makes an interesting group to study

SHRIMP

Bottom: May vary, sand probably best substrate (2 inches sloping)
Filtration System: Small Filter
Feeding: Tiny pieces of frozen shrimp; may eat algae mats; also cannabalistic
Compatible Organisms: Periwinkle Snails, Hermit Crabs
Other: 10 - 15 gallon (number depends on size; very interesting; requires cover

CRABS - Blue

Bottom: Sand 2 1/2 inches deep, some rocks
Filtration System: Filter
Feeding: Frozen Shrimp or Beef Heart
Compatible Organisms: None
Aquarium Size: 10-15 gallons
Other: Very aggressive, size will depend upon number in tank

CRABS - Rock

Bottom: Stones
Filtration System: Filter (Protect with Rocks)
Feeding: Frozen Shrimp, may feed live clam occasionally
Compatible Organisms: Some fish, (Rock Crabs are slow) Hermit crabs, 2 in tank
Aquarium Size: 10 - 15 gallon
Other: Good for display

CRABS - Land

Bottom: 3 inches of dirt, small amount of water (finger bowl, moat)
Filtration System: None
Feeding: Frozen Shrimp and Lettuce
Compatible Organisms: Periwinkle Snails
Aquarium Size: Flat Tank
Other: Keep soil moistened

WORM TANK

Bottom: Sand
Filtration System: None (air stone)
Feeding: Brine Shrimp
Compatible Organisms: Clams
Aquarium Size: Small 1 - 5 gallon
Other:

PLANKTON

Bottom: None
Filtration System: None (air stone)
Feeding: None (expose to sun)
Compatible Organisms: None
Aquarium Size: Flat Tank
Other: Check population change (good for research problem)

DISPLAY OF SPECIMENS

The following is a list of possible display tanks, giving such information as the size of tank you may choose, type of bottom substrate, feeding instructions, etc. Once you and the members of your group have decided upon the type of tank best suited for your collection and set it up, you are responsible for its daily upkeep. A display tank should be pleasing and interesting to observe. A small 3" x 5" typed index card bearing the common name and scientific name of the organisms, along with a brief description of same, would add to the interest of the tank. You may use whatever means you choose to increase the interest and display ability of your tank. This includes using a backdrop or painting the back of your aquarium.

General Rules:

1. Feed organisms on Monday, Wednesday, and Friday. Alternate types of food.
2. Keep front glass clean and the inside of the tank from the water level to the top.
3. If your tank is not all glass, it will be necessary to vaseline the stainless steel parts every two weeks to guard against rust.
4. Wash and dry all equipment after use.
5. Return frozen foods and dried foods to the proper place.
6. Keep the area around the aquarium clean.
7. Tank display and maintenance is a part of your grade.

BARNACLES

Bottom: mostly rocks, may have some sand or gravel
Filtration System: None (Air Stone)
Feeding: Brine Shrimp
Compatible Organisms: Sea Anemone
Other: Very Interesting

CLAMS

Bottom: Soft sand, deep in some places
Filtration System: None (Air Stone)
Feeding: Brine Shrimp; Diatoms possibly
Compatible Organisms: Sea Anemone
Aquarium size: 5 gallon-Donax clams; 15 gallon-Angel Wing or Quahog
Other: Excellent organisms to study; be extremely careful of clams dying and fouling tank. Do not overcrowd.

GOOD AQUARIUM FISH	POOR AQUARIUM FISH (Mortality rate High)
Killifish (all species most hearty)	
Spade Fish	Silversides
Gobies	Sardines
Sargassum Fish	Menhaden
Triple Tail	Pinfish (small)
Sea Robin	
Sea Horses	
Star Gazer	
Flat Fish	
Drums, Croakers, Seatrout	
Catfish (small)	
Pinfish (medium sized)	
Lizard fish	
Pompano	
Jacks	
Lookdown	
Puffer	

I. DO'S FOR MAINTAINING A SUCCESSFUL AQUARIUM

1. Do maintain constant temperature in your tanks.
2. Do keep tanks out of direct sunlight. If this can not be avoided due to room arrangement, then use a backdrop to shield tanks from excessive light.
3. Do remove dead organisms and uneaten food immediately.
4. Do remove sick or diseased organisms. Establish a "Sick Bay."
5. Do maintain a constant water level. Refill with distilled or tap water that has been dechlorinated.
6. Do keep the water well aerated.
7. Do keep the nylon filters clean.
8. Do test a tank for leaks before establishing it with seawater, organisms, etc.
9. Do repair a leaking tank immediately.
10. Do check the pH periodically; "pH" paper strips will suffice.
11. Do keep accurate records as to growth and behavior patterns, diseases and mortality rates.
12. Do leave water in tanks over the vacation period to insure against leaks.

II. DON'TS FOR MAINTAINING A SUCCESSFUL AQUARIUM

1. Don't overcrowd. The rule is: one inch of fish per gallon of water. According to Axlerod and Vorderwinkler (1965) the rule is one inch of fish per two gallons of sea water.
2. Don't lift a full aquarium. Empty it first.
3. Don't overfeed. No more than three times per week for larger organisms.
4. Don't stock your tanks with organisms that cannot adapt to each other. Be selective.
5. Don't clean tanks with detergents. Use tap water followed by a baking soda rinse.
6. Don't clean the inside of tanks with Windex or any other type of glass cleaner.

An Investigation of Tides: Are They Related to the Moon?[1]

All too often we read factual statements that make sweeping generalizations. In the case of the subject of tides we usually find introductory textbooks willing to explain them along the following lines:

1. Tides are known to rise and fall (flood tide and ebb tide) twice during each 24-hour, 50-minute interval, and since this is also the interval between the two successive transits of the moon across a meridian, we know the tides are related to the moon.

2. Since the moon is apparently retarded in the sky by about 50 minutes per day, high tides in any locality are that much later each day also.

Both statements are misleading and ignore the exciting experience of actually investigating the tide-moon relationship. The daily lag in lunar transit is usually shown to be 52 minutes. Teachers who are fortunate enough to live near a seacoast know that the tides are not always 52 minutes later each day. Those of us from the interior are quite puzzled during our seacoast vacation when we follow a particular high-tide sequence. (A specific high-tide sequence is followed by noting the arrival time of every other high tide at a given harbor.) Table 1 lists the arrival time of a specific high-tide sequence at a specific harbor.

A quick glance at Table 1 immediately reveals that the tidal lag interval is not consistently 52 minutes. Rather, the lag interval has a wide range of values: a minimum of 24 to a maximum of 78 minutes. Only when the tidal lag interval is averaged over an entire month is the "about 52 minutes" value obtained. The average lag interval in Table 1 is 49 minutes, which is only "in the ball park."

Therefore, the discrepancies involved in the wide range of values and the 3 minutes difference of the means are enough to question an exact relationship. Any number of excellent teachers have momentarily been on the ropes when a sharp student gleefully points out such discrepancies in a supposedly watertight argument.

Suppose that the teacher assumes that the exact relationship is found in the similar daily behavior of the moon and the tides. The daily lag interval of the moon's transit of the meridian (i.e., its appearance exactly south in the sky) can be extracted from the Ephemeris, [4] which gives daily values of lunar right ascension. The daily change in right ascension is directly proportional to the daily lag interval of the moon's southerly appearance. Table 2 presents the daily change in lunar right ascension for October, 1966, the same dates

[1] Robert G. Anderson, The Science Teacher, April, 1968 364

involved in Table 1.

This phase of the investigation dashes any hopes the teacher may have of quickly showing an exact and obvious relationship between the tides and the moon. The range of lag interval values are not the same: 24 to 78 minutes compared to 43 to 61 minutes. Furthermore, the times at which minimum and maximum lag occur are not always exactly coincident. It is momentarily reassuring to find the coincidence of maximum tidal lag of 78 minutes between the 8th and 9th and the maximum lunar lag of 61 minutes during the same dates. The subsequent minimum tidal lag of 48 minutes between the 11th and 16th seems to coincide with the minimum lunar lag of 54 minutes between the 12th and 15th, adding support to a tide-moon relationship. However, the subsequent maximum tidal lag of 66 minutes occurs about three days after the maximum lunar lag of 59 minutes. The next minimum tidal lag of 24 minutes shows the same trend; it occurs about four days after the middle of the minimum lunar lag of 43 minutes. At this point, the evidence of an exact tide-moon relationship seems somewhat weak, as does the teacher's courage.

By this time also the teacher's research will have established the definite effect of the sun and the complicating factors of the contour of the ocean bottom, depth of water, and even the viscosity of the water itself. [7] But let us return to the problem of exploring the relationship of moon and tides.

There is another approach that occurred to the author: How clear is the relationship between water level and lunar behavior when displayed in graphic form? Does the water level change in step with gravitational forces? Would an inspection of the yearlong pattern make the relationship more apparent than do Tables 1 and 2?

The facts (sometimes called concepts) about tides and their cause tell us that stronger gravitational forces occur during syzygy (full and new moon) and at lunar perigee (closest approach to the earth). When the forces are stronger, the water level should rise higher and fall lower than at other times. The graph should show this effect. Furthermore, the latitude of direct and opposite tides should follow the body causing them, as that body moves north and south of the equator. The effect is most noticeable during the syzygy phases which occur nearest the solstices and equinoxes. This effect should also be apparent in the water-level patterns. Additional relationships were described by S. D. Hicks in his TST article.[7]

The preceding information can either be summarized and stated flatly to the class, or the class can be led to an interesting investigation of the problem. I prefer to allow students the valuable exercise of graphic analysis which will enable them to uncover the relationships mentioned above.

Figure 1 displays several techniques for reducing the time it takes to graph a year's tides. A class of 24 can complete the entire graph during a 50-minute period by splitting each month's data between two students.

A graph scale that has worked well for the tides at the Battery in New York harbor is shown in Figure 1. Charting water-level information for eight days per sheet of paper (with the abscissa the long way) produces a manageable length, even though it takes 48 sheets of paper. An overhead transparency of the student graph sheet allows the instructor to get the class off to a fast start in graphing.

Teachers living in the interior will find the predictions for tides in New York harbor in the World Almanac and Book of Facts,[1] which is usually available in school libraries. If not, the Almanac is frequently found in paperback at book counters. The official tide tables [2] include the necessary lunar data, which can also be found in The Observer's Handbook [3] or The American Ephemeris. [4]

Figure 2 presents a completed chart of a year's tide (water level) patterns. Paper cut-outs mark the lunar positions on the date of their occurrence. Careful inspection of Figures 2 and 3 a, b, and c, should enable the student to answer the following questions:

1. How would you describe the behavior of all high tides? Are they equally high?

2. What did you find happening to the lowest water levels? Are they all equally low?

3. How would you describe the pattern of highest highs and lowest lows which occur during the span of a year?

4. Are the tides consistently related to the moon's phase?

5. Does the moon's orbital position (apogee, perigee) have a consistent influence? If so, in what manner?

6. Does perigee always occur at full moon? If not, how does this affect the problem of predicting tides?

7. What is different about the successive high tides during the solstices as compared to the equinoxes?

8. Summarize, in terms of gravitational forces, the graphic evidence of a relationship between tides and lunar positions.

The author has found that student questions frequently lead to additional investigations of tide-moon relationships. The preceding questions are not expected to be exhaustive; it would be disappointing if they were. Some questions suggested by students were as follows:

1. Do all harbors have two high tides daily?

2. What is the water-level pattern for the Bay of Fundy? for San Diego?

3. Does the altitude of the moon over a harbor affect the tides?

4. Is the changing tidal lag interval related to perigee of the moon?

The origin of this investigation may interest, as well as encourage, the reader. Once upon a time the author questioned one of his teachers concerning the peculiar behavior of the tidal lag intervals in view of the traditional "52 minutes" proof quoted in most introductory texts. Receiving no satisfactory answer was sufficient stimulus to stubbornly dig out the exact relationship. The moral of this story seems to be that "occasionally a true teacher does most for his students by admitting he doesn't know the answer."

Classroom trial of this investigation was obligingly carried out by teachers in the ESCP trial center in the vicinity of Rochester, New York. Junior and senior high school students successfully uncovered the "exact tide-moon relationship" in this process of graphic analysis.

Following is a list of reference material which has been helpful to the author in developing the preceding investigation:

1. The World Almanac and Book of Facts (revised annually). Newspaper Enterprise Association, Inc., World Almanac Division, 230 Park Avenue, New York 10017.

2. Tide Tables, East Coast of North and South America. (A similar volume is available for the West Coast). U.S.Government Printing Office, Washington, D.C. 20402. $2 each.

3. The Observer's Handbook for 1966 (revised annually). The Royal Astronomical Society of Canada, 252 College Street, Toronto 2B, Ontario. $1.

4. The American Ephemeris and Nautical Almanac (1966) (revised annually). U.S.Government Printing Office, Washington, D.C. 20402. $3.75.

5. Darwin, George Howard. The Tides and Kindred Phenomena in the Solar System. W. H. Freeman and Co., San Francisco, Calif. 1962.

6. Defant, Albert. Ebb and Flow: The Tides of Earth, Air, and Water. The University of Michigan Press, Ann Arbor, Mich. 1958.

7. Hicks, Steacy D. "Ocean Tides." The Science Teacher 32:11-14; December, 1965.

Table 1. Tidal lag at the Battery in New York harbor, October 1966

Date	Time of high water *	Lag interval
		minutes
1	0906	
2	0936	30
3	1000	24
4	1036	36
5	1124	48
6	1218	54
7	1324	66
8	1436	72
9	1554	78
10	1700	66
11	1800	60
12	1848	48
13	1936	48
14	2024	48
15	2118	54
16	2206	48
17	2306	60
18	2400	54
19	0000	
20	0100	60
21	0154	54
22	0300	66
23	0400	60
24	0454	54
25	0542	48
26	0624	42
27	0700	36
28	0730	30
29	0806	36
30	0836	30
31	0900	24

* 24-hour time system.

Table 2. Daily change in lunar right ascension during October 1966

Date	Right Ascension	Lag interval
		minutes
1	01h 23m	
2	02h 07m	44
3	02h 53m	46
4	03h 42m	49
5	04h 35m	53
6	05h 30m	55
7	06h 29m	59
8	07h 29m	60
9	08h 30m	61
10	09h 29m	59
11	10h 26m	57
12	11h 22m	56
13	12h 16m	54
14	13h 10m	54
15	14h 04m	54
16	15h 00m	56
17	15h 57m	57
18	16h 56m	59
19	17h 55m	59
20	18h 53m	58
21	19h 49m	56
22	20h 42m	53
23	21h 32m	50
24	22h 19m	47
25	23h 03m	44
26	23h 46m	43
27	00h 29m	43
28	01h 12m	43
29	01h 55m	43
30	02h 41m	46
31	03h 30m	49

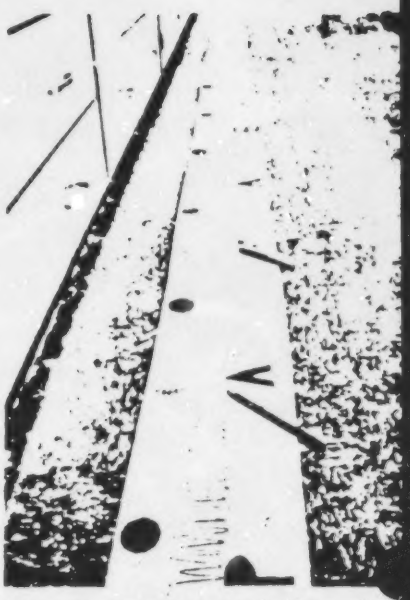


Figure 2. Chart of a year's tide patterns

Figure 1. Graph scale for the tides at the Battery in New York harbor.

PHOTOGRAPHY BY THE AUTHOR

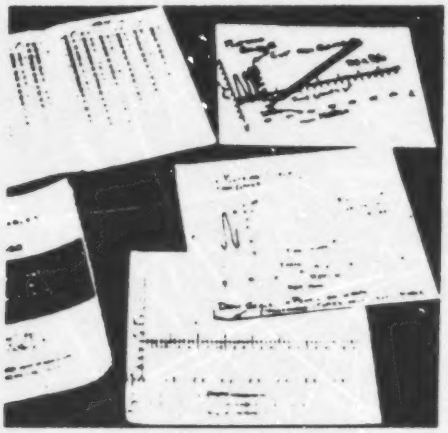
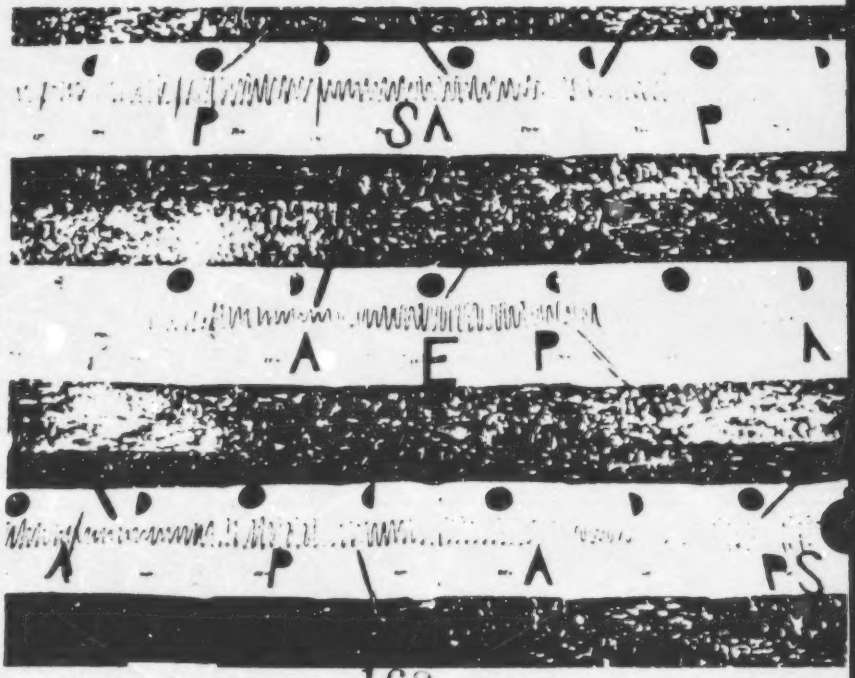


Figure 3. Detail sections of year's graph show use of cut-outs to mark lunar positions



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GALVESTON BAY

In spite of all the abuses to which Galveston Bay has been subjected, it is still the most productive area of the Texas coast line. But Galveston Bay has been sorely damaged, and it is still too soon to learn if the injuries will prove to be irreversible.

To understand the coastal bays of Texas, it is necessary to know a little of their history. Fifteen thousand years ago the world was locked in the grip of the glaciers, and so much of the world's supply of water was tied up in these sheets of ice that sea level fell some 300 or 400 feet. That would have placed the Texas coast line 50 to 100 miles seaward of its present position.

Rainfall was greater during those glacial times and the ancient Sabine, Trinity, Brazos, Colorado, Nueces, and Rio Grande rivers were larger than today and were better able to erode their channels into deep and narrow canyons.

By 10,000 years ago, the glaciers were rapidly receding and by 5,000 years ago sea level had returned to its present stand. The rising sea flooded into the canyons of the lower river valleys, and for a time the Texas coast line must have resembled the fjord topography of Norway. These long and narrow bays were the beginning of the present major bays of the Texas coast.

As soon as the bays were formed, however, they began acting as sediment traps for the rivers. The sediment load that a stream can carry is determined by its velocity, and as soon as the turbid water of a river enters calmer way water, a delta deposit begins to form at the head of the bay.

Wind and wave action have also played an important role in shaping the bays. Erosion at the margin has gradually widened the bays and contributed much of the sediment that has filled the former deep and narrow channels.

Wind and wave action offshore added still another important contribution to the coast line. About 3500 years ago a shallow bar, two or three miles offshore and parallel to the coast, began to form. It was composed mostly of sand, and it slowly emerged from the water. It continued to grow seaward, as well as in height, and it formed a continuous chain of barrier islands separated from the mainland by long and narrow lagoons. East and West Galveston Bays are the lagoons formed by Bolivar Peninsula and Galveston Island.

At one time, then, each of the major Texas rivers emptied into a large bay which had its axis at right angles to the coast line. A

series of barrier islands parallel to the coast produced a more or less continuous lagoon which crossed the transverse bays at their lower ends. Galveston Bay still conforms to this configuration, although the Sabine River to the east and the Brazos River to the southwest have brought down enough silt to fill most of their original bay and lagoon systems.

The Trinity River has built a small delta across the upper end of Galveston Bay, but the San Jacinto River and Buffalo Bayou were not forming a delta, even before the ship channel was dredged in their lower course. In the undisturbed sequence of events, Galveston Bay should persist as a productive estuarine environment for many thousands of years.

An estuary is the place where the waters of the land meet the water of the sea. It is often a difficult environment for plants and animals because it is subject to such a wide range in the temperature and salinity of its waters. But for those species which can tolerate these extremes, an estuary periodically provides the necessary conditions for almost unlimited production.

The estuary, through the runoff of the streams emptying into it, is constantly being supplied with nitrates, phosphates, and all the other required nutrients for plant growth. The estuary concentrates and holds these minerals, rather than dispersing them as occurs in the open sea. In the shallow water of the estuary the sun warms the water and provides the necessary energy for photosynthesis, the real source of practically all human food.

Plant growth, and photosynthesis, are quite different when aquatic crops are compared to crops grown on land. Practically all of the plants a farmer knows are the flowering and seed bearing plants, but only the algae grow in significant usable quantities in the estuaries and in the sea. To make things worse, so far as harvesting this aquatic crop is concerned, most of the algae are the microscopically small diatoms that hang suspended in the water.

Because of the small size of the diatoms, only very small animals, or larger animals with an effective sieve apparatus, can harvest them. The food chain in an estuary is generally based on a standing crop of diatoms being eaten by small shrimp-like crustaceans called copepods. The copepods are in turn eaten by small fish, and these are eaten by larger fish. At each link in this food chain, however, 90 percent of the original nutrient material produced by the diatoms is lost. Only 10 percent is converted into the tissues of the animal eating it. For example, it takes 1000 pounds of diatoms to produce 100 pounds of copepods. These in turn can be converted into 10 pounds of menhaden and ultimately into 1 pound of trout or redfish. How could a farmer survive if he had to supply 1000 pounds of grain to produce 1 pound of beef or pork?

These are the biological facts of Galveston Bay. It is an extraordinarily productive bay because of the fertile soil in its watershed.

It is large enough so that in spite of occasional flood or drouth, there is always a large region in which the fresh and salt waters combine to provide the optimum salinity for estuarine production. The shallow flats which form the margin of the bay are the sheltered nursery grounds for the young and larval stages of shrimp, crabs, and fish.

The monotony of the flat bottom in the deeper waters is broken by mounds and ridges of living oyster reefs. The flow of water is accelerated as it passes over these reefs, and the turbulence maintains the productive diatoms in suspension and also aids in the transfer of oxygen into the water.

In the deeper and calmer water between the reefs, all the debris from the production in the upper water layer slowly settles to the bottom. Here it is carefully sorted from the sand and clay by the white and brown shrimp which invade the bays each year to feed and grow on the bounty of diatom creativity.

What I have described is Galveston Bay as it once was. Desecration of the environment began, however, as soon as towns began to spring up on its borders. Industrial and organic pollution have now produced a heavy black sludge that floors most of the upper bay in places to a depth of two feet. Of course, all bottom productivity in these areas is destroyed, and no one knows whether it can ever be restored.

Seventy-five years ago, a hide and tallow plant was operated at San Leon on the west side of Galveston Bay. Most of the cattle for the plant were driven across the Bay from Smith's Point. They walked across on an almost unbroken chain of oyster reefs that were exposed at low tide. Shortly after that, the shell dredgers moved in, and you know where those reefs and most others are today.

Most recently, a new hazard has threatened Galveston Bay. The shallow flats that are the prime nursery grounds for most of the commercially important species are being drained and filled for housing developments. Galveston Bay has not yet lost many of its flats in this manner, but the trend has begun. It could be controlled now before we are in the position of Florida and many of the other eastern states where the loss has passed the point of no-return.

I read in the paper this morning that President Johnson is asking for $1.2 million dollars for conservation. I would like to suggest that much can be done, and Galveston Bay could be started on its road to recovery now without any Federal Program or Federal Tax Dollars. I would like to request that the following steps be considered:

1. All of the political bodies that border Galveston Bay and its tributaries must agree on a unified program for improving sewage treatment facilities. Only when the sewage problem is improved can effective pressure be placed on industries to solve their waste problems.

2. Shell dredging should be restricted or stopped entirely until a long-term assessment of their damage to the ecology of the Bay can be determined. It took 10,000 years for the shell reefs to form and they are being destroyed in a lifetime. The value of the live oyster has been neglected in Texas. The State even took the name "Oyster" out of its "Game and Fish Commission" a few years ago. But the oyster is perhaps our best marine asset. It feeds directly on diatoms and is 100 times more efficient in converting plants into usable human food than the trout or redfish.

3. A program to limit the encroachment of housing developments on the Bay flats should be enacted.

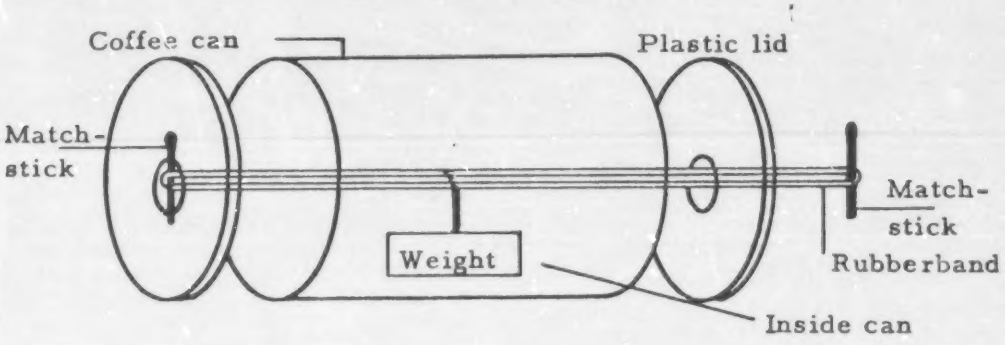
4. The State of Texas should reestablish the "Game, Fish, and Oyster Commission" and separate it from the "Parks Commission." The functions are different and the training for their personnel is different. The "Game, Fish, and Oyster Commission" should try to hire the best qualified men in their field and give them the authority to perform their duties effectively without political control.

I sincerely believe that the best thing that could happen for Galveston Bay would be a well-paid, non-political, professionally trained staff of marine scientists with authority to control the commercial exploitation of the Bay's many resources for the benefit of the greatest number of citizens, rather than for a chosen few.

A talk given by Dr. T. E. Pulley, Director of the Houston Museum of Natural Science at the annual meeting of the National Wildlife Federation May 9, 1968.

THE ACTIVITY:

Preliminary Activity: We can make a simple moving device from a coffee can with two plastic lids, two matchsticks, a rubber band, and a hanging weight. See the sketch below.



If you happen to have metric weights with hooks on them in your laboratory, you're in luck. Otherwise you can improvise (we used a short piece of pipe) and bend a paper clip for the hook. To demonstrate with the can, wind it up by rotating it in your hands for several turns. If you put it on a smooth floor, it should roll away as the rubber band inside unwinds.

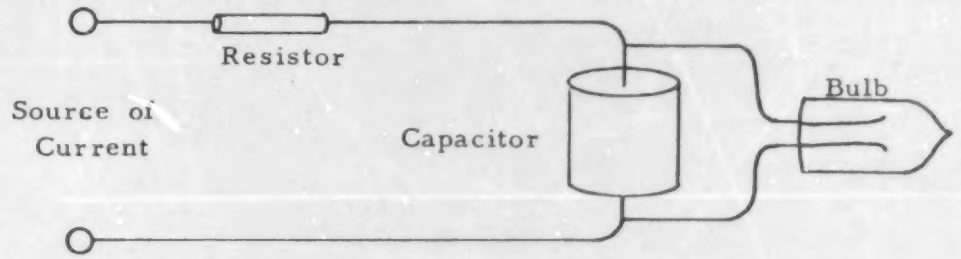
Velocity is the rate of change of position. We need to measure the change of position (distance) and the time required to make this change. Much of the success of this activity depends upon dividing the labor within each lab group of four students. Each group will need one person to start and one person to stop the can. These students can mark the beginning and ending points of the motion. The group also needs a time keeper. This person is in charge of the timer. The time keeper says, "go" and counts the seconds until the stopper says, "stop". The number counted is a measure of the time required for the change in position. Finally, the group needs a person who will measure the distance in centimeters between the starting and the stopping points.

Divide the distance measurement by the number of seconds (watch that decimal point!). Trade assignments and repeat the activity until everyone has had a chance to do the different jobs.

REFERENCE MATERIAL FOR EXPERIMENT FIFTEEN:

How the Pippenblooper Works

The secret of the pippenblooper really lies in the flashing neon bulb. This bulb lights as electricity jumps across the two prongs visible inside the bulb, which cannot happen until the energy of the charge reaches a certain minimum value in volts. The basic circuit looks like the following:



The capacitor is really two thin sheets of metal, separated by waxed paper and rolled into a cylinder. As more and more electrical charges flow onto these plates they gain in energy since charges repel each other. When the energy per charge (measured in volts) is large enough, the charges can flow out of the capacitor and jump across the two prongs in the bulb.

The resistor in the circuit does what its name implies; it resists the flow of electric charge. Thus its value controls how rapidly the charges can move from the source of electrical current onto the plates of the capacitor where they accumulate until they have enough energy to fire the bulb. As the bulb fires, the charges move off the plates of the capacitor through the bulb and back to the source of electrical current. The process then repeats, with charges moving through the resistor onto the capacitor until they have accumulated enough energy to fire the bulb again. This means that we can control the rate of bulb flashing by controlling the rate at which the charges flow onto the capacitor. This is done most easily by changing the value of the resistor in the circuit. (It is also true that the construction of the capacitor affects this rate of flow and energy increase, so we could change the value of the capacitor as well. In practice, however, the resistor is the easier one to change.)

There is a circuit like the one we have drawn for each bulb. Since we want the blooper to always flash at the same rate, the elements of its circuit are wired in separately. But the circuit of the pipper includes the plug seen at the top of the box so different resistances can be added to its circuit. To measure time, we simply plug in a resistor of the proper value to cause more rapid flashes. To measure temperature, we plug in a resistor whose electrical value depends upon its temperature (such a resistor is called a thermistor). To measure light intensity we plug in a vacuum tube which works a little differently. If you look at the tube, you will see a curved metal plate with a wire sticking up in the center. When light particles (photons) hit the plate they knock electrons off (much like bullets would knock pieces of concrete off if fired at a concrete block wall). These electrons are then free to move from the curved plate to the wire, forming a flow of electric current. The rate of this flow of current depends upon how fast the electrons are knocked out of the curved plate, and that depends upon the intensity of the light striking the tube. In other words, the speed of the pipper flashes depends upon the intensity of the light which strikes the tube.

Since the current we use in these circuits must always flow in the same direction (and since the current from the wall plug changes direction 120 times every second), the box also contains a rectifier to direct the current in one direction, plus some extra resistor and a capacitor to make sure the energy is consistent.

How to Use the Pippenblooper to Measure Light Intensity

Put the pippenblooper on the table. Turn the box so the tube faces a window straight-on. You can judge this by looking at the shadow of the tube-base which falls across the top of the pippenblooper box. This shadow should be exactly in the middle of the box. When you think you have the box lined up, have your teacher check you. Count the number of pips during one bloop of time. Make three or four measurements until you can determine what the best value for the number of pips really is at this position.

Now set the pippenblooper on end so the tube faces the ceiling lights. Again count the number of pips during one bloop of time. (If the pips come too fast to count, ask your teacher to turn off some of the room lights.) How does the number of pips in a bloop seem to be related to the brightness of the light?

A "MEASUREMENT" EXERCISE:

Part One:

Set pippenbloopers on the lab table (using the phototubes). Ask each lab group to measure the box.

The secret of success, of course, is detecting a change in the rate of flashing of one of the bulbs. If your class is using the phototube without success, you might innocently draw the window shades (or turn off the room lights on the pretext of seeing the flashes better).

The goal here is to explain the kind of outside action which makes the flash rate change and to determine that there are two different and independent flash rates. (It is not important to understand how the box works on the inside. However, you will find a page explaining the construction of the box for those students who have a special interest in electronics.) This sub-activity will obviously take much less than a class period. The objective is to get the students to explain to each other how one would go about using the box.

In the rest of the material, we will refer to the fast light and the slow light as the "pipper and the blooper," respectively. The only possible logical extension of this is to call the box the "Pippenblooper." Besides, we can't call it a blinkey since Harvard Project Physics is already using that name for a slightly different box. The blooper is a reference light; its rate of flashing is always the same. On the other hand, the pipper varies; the rate at which it flashes depends upon what it is measuring. This is most easily seen (as we have implied) by looking at the behavior of the box with the phototube in use. To use the box, then, involves counting the number of pips that occur in a bloop of time (note that a pip and a bloop are the intervals between flashes).

Part Two:

Replace the phototube with the timing plug. With the black plug on top, both of the lights measure time. The fast one measures a "pip" between flashes. The slow one measures a "bloop" between flashes. Since these are both times, they should be related

in some way--like the second hand and minute hand of a clock. The relation of the clock is that there are 60 seconds in every minute. How many pips are there in every 1 bloop? Find out.

Did everybody at your table get the same number when they counted? Are you sure that there are always the same number of pips in every single bloop? Do at least ten different counts. Write down your answer for each.

DATA SHEET FOR: A "MEASUREMENT" EXERCISE

To the Student:

Look at the pippenblooper. The fast-blinking light is called the "pipper". The slow-blinking light is called the "blooper". The time between two flashes of the pipper is called a pip. The time between two flashes of the blooper is called a bloop. A pip is a short unit of time similar to a second. A bloop is a long unit of time similar to a minute. Sixty seconds are equal to a minute. How many pips are equal to a bloop? Find out by counting the number of times the pipper flashes during one bloop of time.

_____ pips = 1 bloop

Repeat your counting for nine more tries. Fill in one line for each try:

_____ pips = 1 bloop
_____ pips = 1 bloop
_____ pips = 1 bloop
_____ pips = 1 bloop
_____ pips = 1 bloop
_____ pips = 1 bloop
_____ pips = 1 bloop
_____ pips = 1 bloop
_____ pips = 1 bloop

Are there always the same number of pips in every bloop?
What's the biggest number of pips? _____
What's the best average number of pips? _____
What number must you add to the average to get the biggest number of pips? _____
What number must you subtract from the average to get the smallest number of pips? _____

These last two numbers represent the error or uncertainty of the box. When scientists write numbers with possible errors they often use the form "57+3" where 57 is the best average number for what they are measuring and +3 means add or subtract 3 to get the biggest and smallest numbers. What do you think they do if the add and subtract numbers are not the same? Use this idea to complete the following:

1 bloop = _____ + _____ pips.

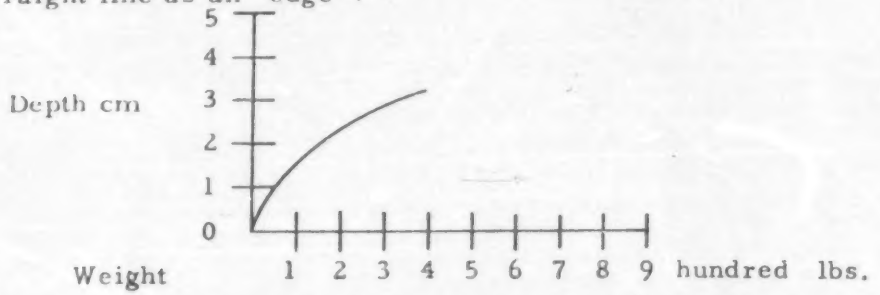
Does the amount of uncertainty depend upon how fast the pipper flashes? If you can adjust the flash rate, speed it up and repeat the exercise.

The following test questions are included as examples of how laboratory work can be included in a written test. No claim is made for the validity of these items. It is expected that they should all be re-worded for each different ability level.

SAMPLE EARTH SCIENCE TEST

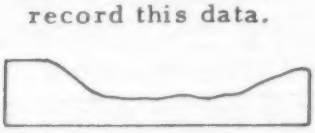
GEOLOGY

1) Why might all of the fossilized tracks sketched above form a straight line as an "edge"?



2) The graph above shows the depth of footprint (for a given print area) as it varies with weight. According to the graph, how deep would the footprint be for a 200 lb. animal?

3) It is found experimentally that a 500 lb. animal makes a footprint that is 5 cm deep. Put an "X" on the graph to record this data.



4) Two plaster-of-Paris "fossils" were sliced in half with a saw; the cross-sections looked like the sketches above. Which represents a cast and which represents a mold? (Write your answer directly on the sketch.)

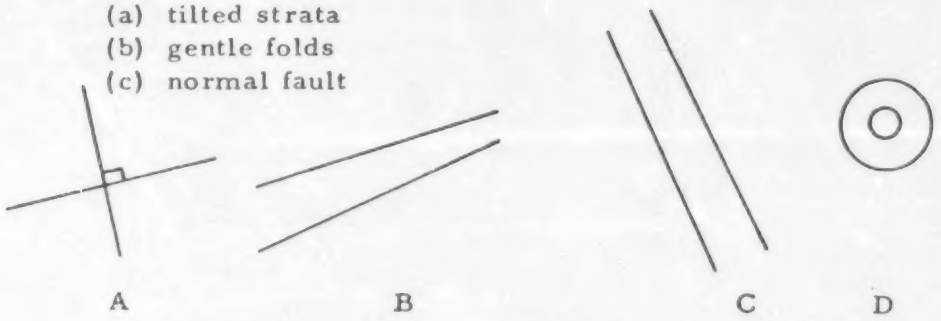
5) Tom scratched an unknown mineral with a nail. Was he measuring streak, hardness, color, or cleavage?

6) Sue put a drop of hydrochloric acid on a piece of limestone. What happened?

7) A soft piece of rock seems to be made of rounded "grains" which are layered. Would you say it was igneous, metamorphic, or sedimentary?

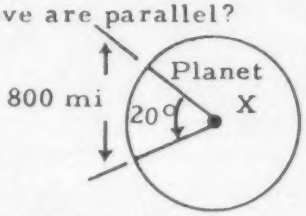
8) Sketch the following deformation patterns:

(a) tilted strata
(b) gentle folds
(c) normal fault

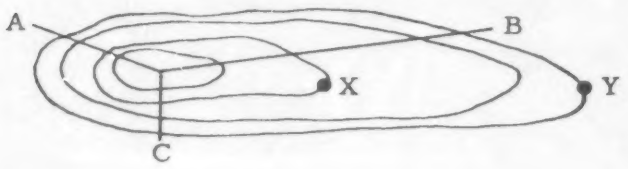


9) Which pair of line segments sketched above are parallel?

10) If the sides of a 20° central angle intercept a distance of 800 miles on planet X, what distance would be intercepted by a central angle of 1°?



11) According to the data given in problem 10, what is the circumference of planet X?



12) A topographic map is sketched above. Imagine that lines A, B, and C represent roads. Which road would be easiest to travel in a Model T Ford (is the least steep)?

13) If the contour interval is 30 feet, what is the difference in height between point X and Y?

14) The region included in the contour map includes a cliff. Put the letter "Z" on the point where you think the cliff most probably is.

15) Draw a profile curve for road B.

OCEANOGRAPHY:

16) Sound waves in water travel at a speed of 4800 ft/sec. If a signal requires 10 seconds to return to the boat, how deep is the ocean floor?

Mass of 100 ml	
Liquid "A"	= 100 g
Liquid "B"	= 113 g
Liquid "C"	= 89 g
Liquid "D"	= 95 g

17) A mass table is given above for four liquids. Which is the most dense?

18) In which liquid would a gydrometer sink deepest?

19) If liquid B and liquid D were poured together, which would probably tend to settle along the bottom of the container?

20) The pressure is measured at a point 5 cm below the surface.

METEOROLOGY:

21) The sun shines on water and on sand for the same length of time. Which will have a higher temperature?

22) The same amount of heat is supplied to a beaker containing 100 g of water and to a beaker containing 100 g of cooking oil. Which has the greatest change in temperature?

23) Name two variables which affect the rate of evaporation.

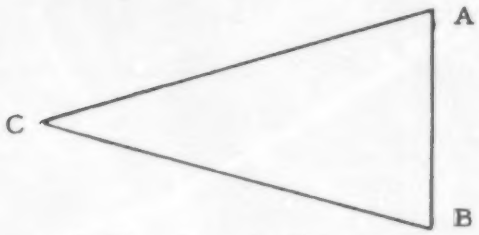
24) On Monday the dewpoint was 38°, and on Tuesday the dewpoint was 45°. On which day was there more water vapor in the air?

25) Which would you expect to be greater--the density of hot air or the density of cold air?

ASTRONOMY:

26) Jim stands 20 feet away from a moving balloon. Peggy stands 100 feet away from the same balloon. Both measure the angular velocity of the balloon. Who will have the biggest value for the angular velocity?

27)

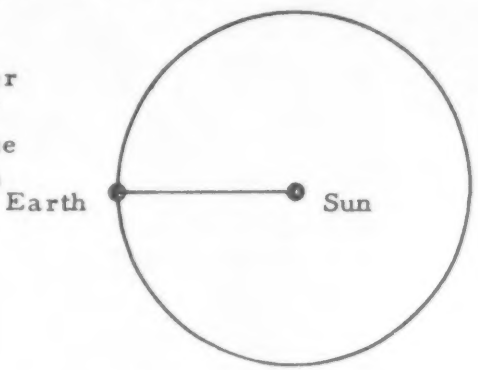


a) How long is line segment AB in centimeters?
b) If the triangle was drawn to the scale 1 cm = 5 miles, what is the distance from A to B in miles?

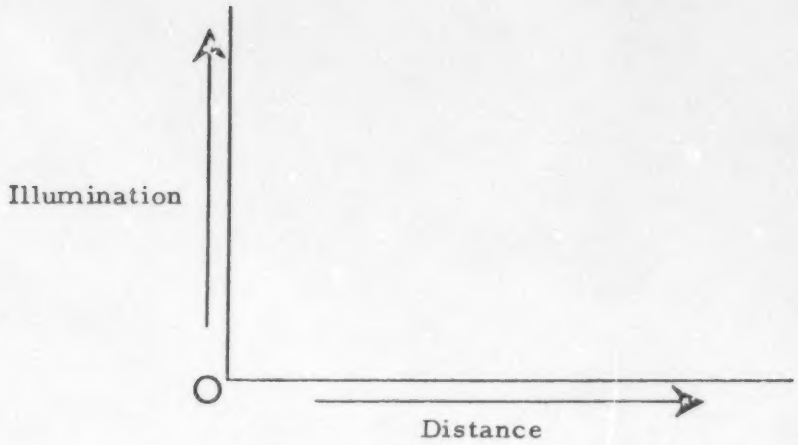
28) Name two things which you can observe that indicate that the moon is moving relative to the sun.

29) What distance did Kepler use as one astronomical unit?

30) Planet X moves in a circular orbit around the sun, but never appears to be farther than 30° away from the sun. Locate the orbit of planet X on the sketch at the right.



31) An experiment is performed to collect data which relates the illumination of a lightbulb to the distance from the bulb. Sketch the general shape which a graph of this data would have in the space drawn on the following page.



32) Star Alpha emits more light in the red end of the spectrum and less light in the blue end of the spectrum than Star Beta. Which star is hottest, Alpha or Beta?

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